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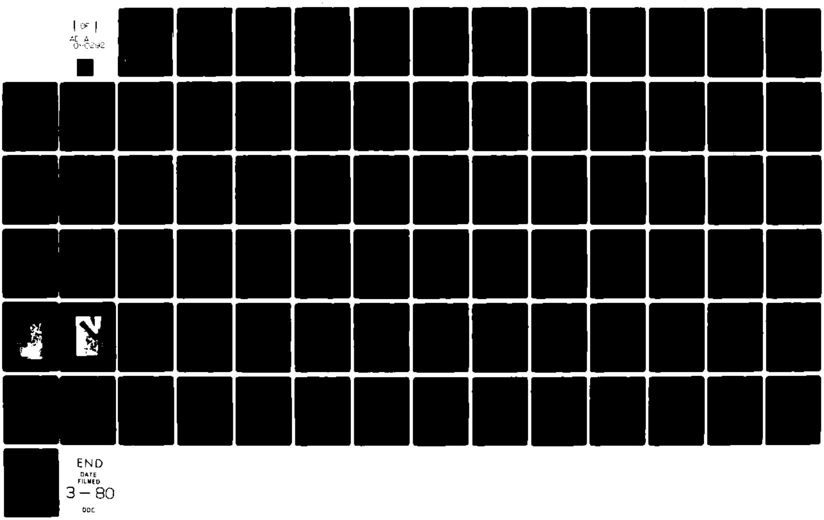

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Modified First-Order	Theodolite	Bias
Astronomic Latitude	Precision	Standard Error
Astronomic Longitude	Accuracy	Correlation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Both First-Order (FO) and Modified First-Order (MFO) astronomic position accuracy figures were determined in this study. Only qualified and experienced observers using refined techniques with Wild T-4 theodolites were evaluated. Only FK4 stars were observed. The Sterneck method of astronomic latitude observation and reduction was employed. Astronomic longitude observations and reduction techniques used the meridian transit method.

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Repeated astronomic observations (majority were simultaneous by 2 to 3 observers) made under normal field conditions by 14 Defense Mapping Agency Hydrographic/Topographic Center Geodetic Survey Squadron (DMAHTC/GSS) personnel during August-November 1977 at station THEODORE, Wyoming, were evaluated. Accuracy terms were computed from pooled FO and MFO residuals from the estimate of the *true* astronomic position of station THEODORE.

The estimated accuracies of both FO and MFO astronomic latitude and longitude, determined by a qualified and experienced DMAHTC/GSS observer using one Wild T-4 theodolite, are as follows:

	Latitude		Longitude	
Type	Accuracy Std. Error	Degrees of Freedom	Accuracy Std. Error	Degrees of Freedom
First-Order	$\pm 0\overset{''}{.}15$	37	$\pm 0\overset{''}{.}25 \sec \phi$	36
Modified First-Order	$\pm 0\overset{''}{.}19$	78	$\pm 0\overset{''}{.}28 \sec \phi$	78

Conclusions concerning correlation between variables were made using various statistical techniques.

An accuracy of $\pm 0\overset{''}{.}09$ (one sigma) of an astronomic latitude determination and an astronomic longitude determination accuracy of $\pm 0\overset{''}{.}14 \sec \phi$ (one sigma) can be achieved by using two different observers and two different instruments with observations collected over five to seven nights.

DMAHTC TECHNICAL REPORT No. 79-002
ASTRONOMIC POSITION ACCURACY CAPABILITY STUDY
PAUL F. GILBERT

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Information added since clearance:

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SUMMARY

Both First-Order (FO) and Modified First-Order (MFO) astronomic position accuracy figures were determined in this study. Only qualified and experienced observers using refined techniques with Wild T-4 theodolites were evaluated. Only FK4 stars were observed. The Sterneck method of astronomic latitude observation and reduction was employed. Astronomic longitude observations and reduction techniques used the meridian transit method.

Repeated astronomic observations (majority were simultaneous by 2 to 3 observers) made under normal field conditions by 14 Defense Mapping Agency Hydrographic Topographic Center Geodetic Survey Squadron (DMAHTC/GSS) personnel during August-November 1977 at station THEODORE, Wyoming, were evaluated. Accuracy terms were computed from pooled FO and MFO residuals from the estimate of the true astronomic position of station THEODORE.

The estimated accuracies of both FO and MFO astronomic latitude and longitude, determined by a qualified and experienced DMAHTC/GSS observer using one Wild T-4 theodolite, are as follows:

	Latitude		Longitude	
Type	Accuracy Std. Error	Degrees of Freedom	Accuracy Std. Error	Degrees of Freedom
First-Order	±0".15	37	±0".25 sec σ	36
Modified First-Order	±0".19	78	±0".28 sec σ	78

Conclusions concerning correlation between variables were made using various statistical techniques.

The astronomic latitude data sample did not contain any significant observer bias. Thirteen of 14 observers have significant personal equations in the astronomic longitude data sample.

Theodolite hardware bias is not significant for any of the three theodolites for both astronomic latitude and longitude data. Significant relative longitude bias is present between results for Wild T-4 120740 and 120741.

Significant additional variation in both the astronomic latitude and longitude set values exists because of between night variance as compared to the within night variance.

The astronomic longitude of a set for this data sample is weakly

correlated with azimuth correction of a set, Greenwich Civil day of a set, and wind azimuth of a set.

Variance of astronomic latitude set data is not a function of the time of night, time since sunset, nor time of year (August through November).

Variance of astronomic longitude set data is not a function of the time of night nor the time since sunset. However, variance of astronomic longitude set data with time of year was found to be significant. This variance correlation is masked in the personal equations of the 14 observers.

Variance of astronomic longitude set data for instrument Wild T-4 120737 is a function of temperature. The value of the astronomic longitude of a set is a function of the temperature of a set only for instrument Wild T-4 120741.

Variance of astronomic longitude set data for instruments Wild T-4 120740 and Wild T-4 120741 are a function of the wind azimuth.

Use of azimuth stars in a set of astronomic longitude does not introduce any significant algebraic bias in the results.

Accuracy of an astronomic latitude set improves as the precision improves. The best accuracy of a set is obtained with eight acceptable stars in a set. The accuracy of an astronomic latitude determination improves from use of only one set per night to four sets per night.

The astronomic longitude accuracy of a set improves as the precision improves. The accuracy of a set does not change from use of 7 stars per set to 10 stars per set. No significant accuracy improvement of an astronomic longitude determination is achieved from use of 2 sets per night to 12 sets per night.

An accuracy of $\pm 0\overset{''}{.}09$ (one sigma) of an astronomic latitude determination can be achieved by using two different instruments and two different observers with observations collected over five to seven nights.

An astronomic longitude determination accuracy of $\pm 0\overset{''}{.}14 \sec \sigma$ (one sigma) can be achieved by using two different observers and two different instruments with observations collected over five to six nights.

Both the value and the variance of an astronomic latitude star pair are not a function of the average zenith distance of the star pair.

For each of the three instruments, no significant differences in the astronomic latitude value between Circle Left and Circle Right observations and between any of the three vertical circle index settings occurs.

PREFACE

This study documents the results of a test authorized by DMATC/GSS OPLAN 77-8040-1, dated 1 August 1977. It determines the best attainable accuracy of conventional astronomic position determinations using only qualified and experienced observers. Wild T-4 theodolites were employed using current field and data reduction techniques with some modifications.

Mr. James K. Barton of the Data Acquisition Branch of GSS for coordination of field operations and preparation of the field operations portion of the report.

Mr. Reeves Krahling and TSgt Bruce Porter of the GSS Survey Reduction Branch for data processing and quality control of the vast amount of astronomic position data observed over a 4-month time span.

Mr. Rudi Salvermoser of DMAHTC/GST for his expert advice in field procedures and calibration techniques which were incorporated in the Operations Plan and executed in the field operations.

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ASTRONOMIC POSITION ACCURACY CAPABILITY STUDY

1. INTRODUCTION. a. A need exists to improve the accuracy of astronomic positions. The conventional methods and procedures employed for observations of first-order (FO) astronomic positions have yielded accuracies of about $\pm 0''.3$ (one sigma) for latitude and $\pm 0''.3$ secant σ (one sigma) for longitude determinations in the past. These accuracy figures were based on observations with several Wild T-4 theodolites and observers of various experience levels.

b. This study was conducted to determine the best attainable accuracy of conventional astronomic position determinations using only qualified and experienced observers and refined techniques. Some refined techniques include: calibration of level vials using the best value as a function of temperature; reading the micrometer of the horizontal circle before and after tracking longitude stars; and not touching the telescope in order to avoid heat transfer. Only FK4 stars were observed. Observations were performed simultaneously by two to three observers. Three of our newer Wild T-4 theodolites were selected for use in this study.

c. Repeated FO astronomic position observations were accomplished from August-November 1977 at three points eccentric to station THEODORE. Fourteen observers using 3 Wild T-4 theodolites observed 38 FO astronomic latitudes and 37 FO astronomic longitudes. Five partial determinations (three to four sets) of both latitude and longitude were made.

d. Accuracy estimates of both FO and MFO astronomic positions are based on residuals of each FO and MFO from an estimate of the true value for station THEODORE. The true value estimate (standard) of astronomic latitude and longitude for station THEODORE was computed from the 1977 observations only. The standard astronomic latitude position is based on 38 FO determinations during 1977. The standard astronomic longitude position is based on 37 FO determinations during 1977. This study has assumed a random effect of all possible nonmodeled error sources. Some of these error sources are:

(1) Star catalog position uncertainties.
(2) Physical phenomena (refraction anomalies, temperature changes, temperature gradients, and wind).
(3) Noise (scintillation, haze, and star background).
(4) Operator's personal equation.
(5) Theodolite constants.
(6) Clock timing errors.
(7) Theodolite hardware biases.

Contributions from each of these error sources are not all identified separately but are included in the accuracy terms addressed in this study.

2. SPECIFICATIONS FOR ASTRONOMIC POSITIONS

a. General. Certain criteria must be met for both FO and MFO astronomic position determinations. The following specifications are contained in TM 5-442 and GSSQ Operating Instruction 8240.2.

b. FO Astronomic Latitude (Sterneck Method):

(1) At least six stars acceptable in each set.
(2) At least six sets acceptable.
(3) Acceptable sets/observed sets $\geq$ 75 percent.
(4) At least 40 acceptable stars.
(5) Precision standard error $\leq 0''.156$.

c. MFO Astronomic Latitude (Sterneck Method):

(1) At least six stars acceptable in each set.
(2) At least three sets acceptable.
(3) Acceptable sets/observed sets $\geq$ 75 percent.
(4) At least 24 acceptable stars.
(5) Precision standard error $\leq 0''.378$.

d. FO Astronomic Longitude:

(1) At least five stars acceptable in each set.
(2) At least five sets acceptable.
(3) Acceptable sets/observed sets $\geq$ 75 percent.
(4) Precision standard error $\leq 0''.156$ secant σ.

e. MFO Astronomic Longitude:

(1) At least five stars acceptable in each set.
(2) At least three sets acceptable.
(3) Acceptable sets/observed sets $\geq$ 75 percent.
(4) Precision standard error $\leq 0''.378$ secant σ.

3. FIELD OPERATIONS

a. General. The astronomic position observations for this study were carried out at three points eccentric to station THEODORE. Station THEODORE is located in the southwestern portion of F. E. Warren AFB, Wyoming. The three points were called THEODORE ECC, TRACY, and JIM and consisted of metal tribrachs plastered to cinder block piers set on concrete bases. Azimuth and distance ties were made to station THEODORE prior to commencement of observations. Wooden platforms and standard astronomic tents were placed around the piers.

b. Equipment. The equipment used in the astronomic observations consisted of:

(1) Three Wild T-4 theodolites with vertical circle drives, modified vertical circle levels and prism attachments permitting the observer to read the hanging level from the eyepiece end of the instrument. Figures 1 and 2 show two views of the modifications to the Wild T-4 theodolite.

(2) Datametrics* timing systems.

(3) Specific Products WWV receivers.

(4) Tektronix oscilloscopes with scope cameras to record the clock synchronizations.

(5) Hamilton and Nardin sidereal rate chronometers.

(6) Barometers and psychrometers.

c. Instrument Calibration. Vertical circle level values, hanging level values, lost motion of the micrometers, and mean width of the contact strips of the micrometers were determined for three instruments in the lab before and after the observations for this study. Level values for these instruments were redetermined in the field when the temperatures encountered during the observations were sufficiently different (10° to 15° F) from the previous determination to warrant another determination. Observations of at least two stars for the determination of the equatorial value of one turn of the micrometer were made on each night during longitude observations. Level values were determined with the levels mounted on the instruments by the Wisconsin and Vertical Circle methods. Data for the determination of the mean width of the contact strips were gathered by attaching a constant speed motor to the micrometer and recording the make-and-break contacts on a tape oscillograph. The lost motion of the micrometer was determined by projecting the image of the crosshairs onto a screen, bringing the images into coincidence from each direction and determining the difference in the micrometer scale readings.

d. Operations. A Wild T-4 theodolite and its associated equipment was assigned to each of the three piers and the observers moved from one pier to another as they completed FO observations at a pier. Enough observers were usually available to allow simultaneous observations by three observers but sometimes only two. Only one observer completed FO observations on one pier without simultaneous observations at another pier. A FO determination consisted of at least eight sets of both latitude and longitude. Eight stars per set were observed. Observations were made only on FK4 stars for latitude and longitude. Some FK4 supplement stars were used only for equatorial value determination. In addition to a recorder for each observer, there was a

* Any mention herein of a commercial product does not constitute endorsement by the United States Government.

coordinator whose job was, among other things, to select the stars to be observed in a set. If one observer missed a star for some reason, another star was selected and all observers observed it. Each observer was to observe one FO determination at each of at least two (later changes to all three) of the piers. There were to be at least 10 observers. Observations were made by a total of 14 observers, 10 of whom completed FO determinations on all 3 piers. There was a total of 38 FO latitudes and 37 FO longitude determinations. There were also five partial determinations (three to four sets) of both latitude and longitude made. In general, the observations followed the instructions in TM 5-442 and GSSQ Operating Instruction 8240.2. The instruments were removed from the piers each night and stored in unheated secure areas. A minimum of an hour was allowed each evening after set-up before observations were begun. The following are the major exceptions to the above-mentioned instructions which were followed throughout the observations.

(1) Latitude Observations:

(a) The zenith distance balance for a set was held to within $\pm 5°$.

(b) The sets were distributed as equally as possible among vertical circle index settings of 0°, 60°, and 120°.

(2) Longitude Observations:

(a) Prism attachments were used to enable the observer to read the hanging level from the eyepiece end of the instrument.

(b) The observations were limited to those stars whose "A" factors were ± 0.6 or less. The exception to this was the azimuth stars (north stars with an "A" factor between -0.6 and -1.0) purposely observed. One or two azimuth stars were observed each night on which longitude observations were made.

(c) The stars were tracked a sufficient distance to provide at least 27 time recordings for both the "in" track and the "out" track (3 revolutions of the micrometer drum).

(d) When the instrument was aligned to the meridian, the horizontal circle micrometer was set up to 10" rather than 00". This enabled the observers to measure a positive value of the misalignment to the meridian. Coincidence was made and the recorder noted the readings before and after the "in" track and before and after the "out" track.

4. DATA PROCESSING. a. Both astronomic latitude and longitude observations were reduced on the GSS IBM 7040/7094 computer system.

Version 1, Modification 14 of the Sterneck Latitude Program was used to reduce astronomic latitude observations. Astronomic latitude data by set have been corrected for final BIH CIO pole, but do not contain sea level corrections. Both FO and MFO data contain final BIH CIO pole corrections and a sea level correction of -0".32. Astronomic longitude observations were reduced using Gregerson's Weighted Astronomic Longitude by Meridian Transit Program, Version 2, Modification 11. Astronomic longitude data have been corrected for final BIH CIO pole and are on the BIH UT1 system. The Meridian Transit Time Program was used to compute star transit times for each astronomic longitude observation on the IBM 7040/7094 computer system. The equatorial radius of the micrometer for each of three theodolites was also computed using this program. For each set of astronomic longitude observations, a plot of time difference (α-t) versus "A" factor was made to assess the quality of the star trackings. Standard error figures in Tables 1-8 and Appendices A and B are precision terms only.

b. Tables 1 and 2 list final astronomic latitude and longitude set results by observer. The weighted mean values represent the estimate of the true value for station THEODORE. YRGCD code of 77216 means Greenwich Civil day 216, year 1977 or 4 August 1977. Each observer's result was weighted by the number of acceptable sets.

c. Tables 3 and 4 list astronomic latitude and longitude results by instruments, respectively.

d. Tables 5 and 6 list 38 FO astronomic latitude (Sterneck Method) results and 79 MFO astronomic latitude results, respectively.

e. Tables 7 and 8 present 37 FO astronomic longitude results and 79 MFO astronomic longitude results, respectively.

f. Appendix A contains data for each observed set of astronomic latitude grouped by observer.

g. Data for each observed set of astronomic longitude, grouped by observer, are shown in Appendix B.

5. DATA ANALYSIS

a. Instrument Calibration Values.

(1) The equatorial value of one turn of the micrometer was computed separately for each observer on each night. An average was computed from the value of all FK4 stars observed by an observer on any given night.

(2) Final values of the mean width of contact strips for each of three instruments are tabulated below:

Instrument Wild T4	1977 Date	Temperature Degrees F	Mean Width of Contact Strip*	Std. Error of Mean*
120737	22 Jul	72	0.86689	±0.00324
120737	15 Sep	72	0.91044	±0.00115
120737	28 Nov	72	0.86262	±0.00169
120740	22 Jul	72	0.90227	±0.00241
120740	9 Sep	72	0.91044	±0.00115
120740	29 Nov	72	0.92553	±0.00265
120741	29 Jul	72	1.22415	±0.00423
120741	9 Sep	72	0.77531	±0.00468
120741	15 Sep	72	0.79974**	±0.00278
120741	29 Nov	72	0.89027**	±0.00487

*Division of the micrometer.
**Different micrometer.

(3) Final static lost motion values of the micrometer were determined for each of three Wild T-4 theodolites used in the study. The table below presents the results:

Instrument Wild T4	Static Lost Motion*	Std. Error of Mean*	No. of Sets	t
120737	0.05358	±0.00803	45	6.67
120740	0.11901	±0.01144	45	10.40
120741	0.06568	±0.00915	45	7.18

*Divisions of the micrometer.

Each set is composed of nine observations, each on a separate wire. An observation consists of a difference of two micrometer scale readings on the same wire. Wires 6 through 14 inclusive were used. The value of t represents the quotient of the static lost motion divided by its standard error.

(4) Hanging level vial sensitivity values were found to be highly correlated with temperature. The following equations apply for temperatures from 35° F to 70° F. Bubble lengths varied about the nominal value of 40 by ±4 (one sigma).

Instrument Wild T4	Vial Number	r^2	Straight Line Equation (Degrees Fahrenheit)
120737	HL802	0.744	D = 1.5413 -0.0086150 (T)
120740	HL882	0.809	D = 1.4468 -0.0035915 (T)
120741	HL883	0.905	D = 0.5896 +0.0058792 (T)

where

r^2	=	coefficient of determination, the degree of relationship between vial sensitivity and temperature. Values close to 1.0 are highly correlated
D	=	level vial sensitivity value in arc seconds/division
T	=	temperature in degrees Fahrenheit.

(5) Vertical circle level vial sensitivity values were not significantly correlated with temperature. Level vial values used represent an average and are as follows:

Instrument Wild T4	Vial Number	No. of Obs.	Value Arc Seconds/Division
120737	VC400	8	1.1558
120740	VC181	10	1.1188
120741	VC365	8	1.2104

b. Explanation of Statistical Tests Used for Data Evaluation.

(1) Residuals of both FO or MFO astronomic position determinations from the estimate of the true value for station THEODORE were pooled. Accuracy estimates were computed using the following formula:

$$\hat{\Sigma} = \sqrt{\frac{\sum_{i=1}^{n} v_i v_i}{(n-1)}}$$

where

$\hat{\Sigma}$	=	estimated accuracy standard error of an astronomic position component
v_i	=	residual of ith determination from station mean
n	=	number of determinations at station.

(2) Both astronomic latitude and longitude data were grouped by theodolite or observer to determine any significant theodolite hardware bias or operator's personal equation. Residuals from the standard for station

THEODORE and a precision standard error of the mean for each group were computed for each position component. A $\underline{t}$ value was determined from the ratio of the residual to its standard error of the mean. This $\underline{t}$ value was tested for significance at the 0.05 test level (two-tailed). If the $\underline{t}$ value exceeded the tabular $\underline{t}$ value, then the theodolite or observer had significant bias.

(3) The Kolmogorov-Smirnov (KS) test was used to test for goodness of fit to a normal distribution. A normal distribution (Gaussian curve) has three properties: small errors are more frequent than large errors; very large errors are unlikely to occur; and positive and negative errors of the same numerical magnitude are equally likely to occur. Both FO and MFO astronomic latitude and longitude samples were subjected to this test. The assumed hypothesis is that the astronomic data sample is a sample from a normal distribution. If a computed parameter exceeds the tabular value, then this hypothesis can be rejected at the chosen probability level and the data sample in-hand does not conform to normal distribution statistics.

(4) The pooled astronomic data samples, both FO and MFO, were measured for departures from normality. Skewness is a measure of the asymmetry of a data sample distribution. Kurtosis (peakedness) is a measure of the flatness or slenderness of the data sample distribution. A leptokurtic (slender) distribution has many small errors and few large errors. A platykurtic (flat) distribution has many large errors as well as small errors. Coefficients of skewness and excess were calculated from the sample moments. The kurtosis was determined from the coefficient of excess. For a normal distribution, both coefficients are zero and the kurtosis is three.

(5) Variance is defined as the mean square deviation from a mean. The square root of the variance is called the standard deviation. Analysis of Variances (ANOVA) involves the comparison of sums of squares of deviations of observations from various means. It allows the separation of total variance into its component parts. The estimated variance within a class is a yardstick of chance variance. The variance between classes is a component part that can be tested by statistical means. The null hypothesis states there is no additional variation in the data sample due to class effects. It is subjected to an $\underline{F}$ test. If the sample $\underline{F}$ ratio exceeds the tabular $\underline{F}$ value at a chosen probability level, then this hypothesis can be disproved.

(6) Variances of various groupings of astronomic set observations were tested for homogeneity using Bartlett's test. A statistic, $\underline{M}$, is calculated from the pooled variance and the individual variances. The distribution of $\underline{M}$ is satisfactorily approximated by the Chi-Squared function if all degrees of freedom are greater than five. The assumed null hypothesis is that all variances from the various groupings of astronomic data are equal. If the statistic $\underline{M}$ exceeds the tabular Chi-Squared value, then this hypothesis is rejected at the chosen probability level and one can conclude that one or more group's variances are excessive.

c. FO Astronomic Latitude (Sterneck Method) Analysis.

(1) Table 5 lists 38 FO astronomic latitude residuals from the standard astronomic latitude for THEODORE. These residuals were pooled to produce an estimated accuracy standard error of a FO astronomic latitude observed by a qualified GSS observer using one instrument. The estimated accuracy of a FO astronomic latitude (Sterneck Method) is $\pm 0''.15$ (one sigma). The true accuracy standard error of a GSS FO astronomic latitude is contained in the 95-percent confidence interval from $0''.12$ to $0''.19$.

(2) Figure 3 is a frequency diagram showing the distribution of these 38 FO astronomic latitude differences from the standard astronomic latitude for station THEODORE. This sample of 38 FOs yielded coefficients of skewness and excess of 1.05 and 1.39, respectively. The kurtosis of 4.39 indicates a leptokurtic distribution. The KS Test of Goodness of Fit was used to verify or refute that this sample is from a normal distribution. The null hypothesis of this sample being normally distributed could not be disproved at the 0.05 test level.

d. MFO Astronomic Latitude (Sterneck Method) Analysis.

(1) Table 6 lists 79 MFO astronomic latitude residuals from the standard astronomic latitude for station THEODORE. These 79 residuals were pooled to yield an estimate of an accuracy standard error of a MFO astronomic latitude. A one sigma value of $\pm 0''.19$ represents an estimated accuracy of a MFO astronomic latitude observed by a qualified GSS observer using one instrument. The 95-percent confidence interval from $0''.17$ to $0''.23$ contains the true accuracy standard error of a GSS MFO astronomic latitude.

(2) Figure 4 is a frequency diagram displaying 79 MFO astronomic latitude residuals from the estimate of the true value for station THEODORE. Coefficients of skewness and excess are 0.20 and 1.11, respectively, for this sample. The kurtosis of 4.11 indicates a leptokurtic distribution. The KS Test of Goodness of Fit was used to verify or refute that this sample is from a normal distribution. The null hypothesis of this sample being normally distributed could not be refuted at the 0.05 test level.

e. FO Astronomic Longitude Analysis.

(1) Table 7 presents 37 FO astronomic longitude residuals from the standard astronomic longitude for station THEODORE. An estimate of the accuracy of a FO astronomic longitude was produced by pooling these 37 FO residuals. The estimated accuracy standard error of a FO astronomic longitude is $0''.25$ secant σ observed by a qualified GSS observer using one instrument. The true accuracy standard error of a GSS FO astronomic longitude is contained in the 95-percent confidence interval from $0''.20$ secant σ to $0''.33$ secant σ.

(2) Figure 5 is a frequency diagram showing the distribution of 37 FO astronomic longitude differences from the standard astronomic longitude for station THEODORE. This sample of 37 FOs produced coefficients of skewness and excess of -0.21 and -0.28, respectively. The kurtosis of 2.72 indicates a platykurtic distribution. The KS Test of Goodness of Fit was used to verify or refute that this sample is from a normal distribution. The null hypothesis of this sample being normally distributed could not be disproved at the 0.05 test level.

f. MFO Astronomic Longitude Analysis.

(1) Table 8 displays 79 MFO astronomic longitude differences from the standard astronomic longitude for station THEODORE. These 79 residuals were pooled to yield an accuracy estimate of a MFO astronomic longitude standard error. A one sigma value of $\pm 0''.28$ secant σ represents an estimated accuracy of a MFO astronomic longitude observed by a qualified GSS observer using one instrument. The 95-percent confidence interval from $0''.24$ secant σ to $0''.33$ secant σ contains the true accuracy standard error of a GSS MFO astronomic longitude.

(2) Figure 6 is a frequency diagram displaying the distribution of 79 MFO astronomic longitude residuals from the standard astronomic longitude for station THEODORE. Coefficients of skewness and excess are -0.33 and -0.28, respectively, for this sample. The kurtosis of 2.72 indicates a platykurtic distribution. The KS Test for Goodness of Fit was used to verify or refute that this sample is from a normal distribution. The null hypothesis of this sample being normally distributed could not be refuted at the 0.05 test level.

g. Analysis of Observer and Instrument Bias.

(1) Table 1 presents the composite set results of astronomic latitude data by observer. Each of the 14 observer's mean astronomic latitude value is within $\pm 0''.10$ of the weighted mean for station THEODORE. The quotient of the residual of an observer's mean value from the standard divided by his standard error of the mean produces a t value. None of the t values are significant at the 0.05 test level (two-tailed). No significant observer bias is present in this astronomic latitude data sample.

(2) Table 2 lists composite set results of astronomic longitude data by observer. The t value of each of 14 observers was tested for significance at the 0.05 test level (two-tailed). All observers, except one, have significant personal equations for astronomic longitude observations.

(3) Table 3 displays the final astronomic latitude results for each of the three Wild T-4 theodolites used in the study. The t value for each of the three instruments was tested for significance at the 0.05 test level

(two-tailed). None of the three instruments contains significant astronomic latitude bias.

(4) Table 4 lists final astronomic longitude results for each of three Wild T-4 theodolites used in this study. The t value for each of the three instruments was tested for significance at the 0.05 test level (two-tailed). None of the three instruments contain significant astronomic longitude bias. However, there is significant "relative" bias between results for instruments Wild T-4 120740 and 120741 at the 0.05 test level.

h. Analysis of Variance.

(1) Astronomic latitude total set variances were separated by FO, by MFO, and by nights. Tables 9, 10, and 11 present the statistical information for each ANOVA case. Each of the three F ratios is significant at the 0.05 probability test level. There is significant additional variation in the astronomic latitude set values because of between FO variance, between MFO variance, and between night variance.

(2) Astronomic longitude total variances of set results were separated in three classes: by FO; by MFO; and by nights. Tables 12, 13, and 14 list the statistical data for each of the three ANOVA cases. Each of the three F ratios is significant at the 0.05 test level. There is significant additional variation in the astronomic longitude set values because of between FO variance, between MFO variance, and between night variance.

i. Multiple Regression Analysis.

(1) The 338 sets of astronomic latitude data were subjected to a multiple regression analysis. The dependent variable was the astronomic latitude for a set. Eleven independent variables of a set were:

(a) Zenith distance sum.
(b) Zenith distance average.
(c) Wind azimuth.
(d) Wind speed.
(e) Absolute zenith point correction.
(f) Greenwich Civil day.
(g) Time of night.
(h) Atmospheric pressure.
(i) Ambient temperature.
(j) Variance of star residuals within set.
(k) Time span.

At the 0.05 test level, none of the 11 independent variables was significantly correlated with the astronomic latitude of a set.

(2) Multiple regression analysis was performed on the 324 sets of astronomic longitude data. The dependent variable was the astronomic longitude for the set. Independent variables of a set were:

(a) Azimuth correction.
(b) Summation of "A" factor.
(c) Time span.
(d) Greenwich Civil day.
(e) Time of night.
(f) Atmospheric pressure.
(g) Ambient temperature.
(h) Wind azimuth.
(i) Wind speed.
(j) Variance of star residuals within set.

Three independent variables are weakly correlated with the astronomic longitude for a set. They are azimuth correction, Greenwich Civil day, and wind azimuth. The pertinent information is listed below:

Independent Variable	Regression Coefficient	Std. Dev. of Regression Coeff.	t	Correlation With Longitude
Azimuth correction (time sec)	-0.00632	$\pm$0.00280	-2.26	-0.08
Greenwich Civil day	0.00024	$\pm$0.00005	4.98	0.25
Wind azimuth (degrees)	0.00004	$\pm$0.00002	2.22	0.11

Data in the fourth column under t represents a quotient of the regression coefficient divided by its standard deviation. These values were subjected to a t test at the 0.05 test level with 320° of freedom. Each of the t values for a variable was significant. The fifth column represents each independent variable's correlation with the dependent variable. The coefficient of determination for the multiple correlation is 0.088.

j. Correlation of Astronomic Latitude With Time.

(1) Investigation of set residuals of astronomic latitude observations with time of night was accomplished. Figure 7 displays each of 338 set values from the standard for THEODORE, 41°08'05".02 N, as a function of local time of night. Table 15 presents the data grouped by every 2 hours except the first group, which is about 3 hours. Bartlett's test was used to verify if each of the four group variances belongs to the same population of variances. Table 16 lists the pertinent statistics for each instrument and for all three instruments. Each of the statistic M values is less than the critical value at the 0.05 test level. Hence, homogeneity of the four group variances cannot be disproved for each instrument and for all three instruments. Variance of astronomic latitude set data is not a function of the time of night.

(2) Analysis of astronomic latitude set residuals with time since sunset was done. Table 17 lists the data grouped by every 2 hours. Homogeneity of the four group variances was tested using Bartlett's test. Table 18 presents the relevant statistics for each instrument and for all three instruments. Each of the statistic M values is less than the critical value at the 0.05 test level. Homogeneity of the four group variances cannot be discredited for each instrument and for all three instruments. Variance of astronomic latitude set data is not a function of the time since sunset.

(3) Astronomic latitude set residuals were plotted as a function of the time of year. Figure 8 portrays each of 338 set values from the standard as a function of time of year. Table 19 presents the data in five groups. These five groups represent the five deployments at station THEODORE over the time span from 4 August to 16 November 1977. Bartlett's test was employed to affirm if each of the five group variances belongs to the same population of variances. Table 20 lists the statistics for each instrument and for all three instruments. Each of the statistic M values is less than the critical value at the 0.05 probability test level. Homogeneity of the five group variances cannot be refuted for each instrument and for all three instruments. Variance of astronomic latitude set data is not a function of time of year (4 months total in this case).

k. Correlation of Astronomic Longitude With Time.

(1) Investigation of astronomic longitude set residuals with time of night was accomplished. Figure 9 displays 324 set values from the standard for station THEODORE, 104°51'55".34 W, as a function of local time of night. Table 21 presents the data grouped by every 2 hours for each instrument and for all three instruments. Homogeneity of the four group variances was tested using Bartlett's test. Table 22 lists the necessary statistical data for each instrument and for all three instruments. Each of the values for the statistic M is less than the critical value at the 0.05 test level. Hence, homogeneity of the four group variances cannot be refuted for each instrument or for all three instruments. Variance of astronomic longitude set data is not a function of the time of night.

(2) Analysis of astronomic longitude set residuals with time since sunset was accomplished. Table 23 lists the data grouped by every 2 hours. Bartlett's test was used to verify if each of the four group variances belongs to the same population of variances. Table 24 lists the pertinent statistical information for each instrument and for all three instruments. Each of the statistic M values is less than the critical value at the 0.05 probability test level. Homogeneity of the four group variances cannot be discredited for each instrument or for all three instruments. Variance of astronomic longitude set data is not a function of time since sunset.

(3) Astronomic longitude set residuals were plotted as a function

of the time of year. Figure 10 portrays each of 324 set values from the standard as a function of time of year. Table 25 presents the data in five groups. These five groups represent the five deployments at station THEODORE from 3 August through 12 November 1977. Bartlett's test was employed to affirm each of the five group variances belongs to the same population of variances. Table 26 presents the relevant statistical information for each instrument and for all three instruments. Homogeneity of the five group variances for instruments Wild T-4 120737 and Wild T-4 120741 can be disproved at the 0.05 test level.

l. Correlation of Astronomic Longitude With Temperature.

(1) Investigation of astronomic longitude set residuals with temperature was accomplished. Figure 11 displays 324 set values from the standard for station THEODORE as a function of the mean temperature during the set. Table 27 presents the data in five groups of temperature for each instrument and for all three instruments. Homogeneity of the group variances was tested using Bartlett's test. Table 28 lists the relevant statistics for each instrument and for all three instruments. Homogeneity of the four group variances (did not use 15° to 32° F group) for instrument Wild T-4 120737 can be discredited at the 0.05 test level. The noise of the data observed with this instrument decreases as the temperature increases.

(2) Least-squares straight line fits for three subsets and for all the astronomic longitude data were computed. The three subsets were by instrument. The slopes of the straight line fit for instrument Wild T-4 120741 and for the total of all three instruments are significant at the 0.05 test level. The slopes are -0.39 meter/1° F for Wild T-4 120741 and -0.15 meter/1° F for all the astronomic longitude data. The astronomic longitude of a set shifts west as the temperature decreases.

m. Correlation of Astronomic Longitude With Wind Azimuth. Investigation of astronomic longitude set residuals with wind azimuth was done. Figure 12 is a plot of 324 set values from the standard as a function of the wind azimuth (the direction the wind was blowing from) during a set. Table 29 lists the data in five groups of wind azimuth for each instrument and for all three instruments. Bartlett's test was used to affirm if each of the five group variances belong to the same population of variances. Table 30 lists the statistics for each instrument and for all three instruments. Homogeneity of the five group variances (only four for Wild T-4 120740) for all instruments and for Wild T-4 120740 and 120741 can be disproved at the 0.05 test level.

n. Analysis of Azimuth Stars Used for Astronomic Longitude Observations. One or two azimuth stars (stars north of observer's zenith with "A" factors between -0.6 and -1.0) were observed each night by each observer. There were 89 sets with high "A" factor stars included in the result of the set. The sets were computed with and without the high "A" factor stars. Both an

algebraic mean difference (with/without) and an absolute mean difference were computed from the differences of the astronomic longitude sets. The algebraic mean difference is +0".0074 $\pm$0".0086 (one sigma). The spread of the differences is from -0".39 to +0".32. There are 50 positive differences and 39 negative differences (with/without). The absolute mean difference is 0".0535 $\pm$0"0064 (one sigma). There appears to be no significant algebraic bias in the astronomic longitude result when azimuth stars are included in the result of a set.

o. Astronomic Latitude Accuracy Correlation.

(1) Correlation of astronomic latitude accuracy of a set with four parameters was analyzed. Parameters are set precision, number of stars per set, number of nights between two sets, and number of sets meaned per night. Astronomic latitude data from sets observed from 3 August to 12 November 1977 at station THEODORE were used for this analysis. Residuals of each set, pair of sets or combination of sets were computed as a deviation from the standard. Accuracy figures were determined from these residuals. Homogeneity of variances was tested using Bartlett's test.

(2) Table 31 presents the relationship of accuracy to precision for one set of astronomic latitude. Homogeneity of variances between the six classes can be disproved at the 0.05 test level. Accuracy improves as precision improves. The ratio of accuracy to precision varies from 1:1 to 2:1 as the precision improves. The class with the best precision had an accuracy figure twice the precision term.

(3) Table 32 shows the relationship of accuracy to the number of acceptable stars in a set of astronomic latitude. At the 0.05 test level, homogeneity of variances could be refuted between the four classes. The best accuracy figure is obtained with eight acceptable stars in a set. Use of only six stars in a set degrades the accuracy too much.

(4) Table 33 displays the relationship of astronomic latitude accuracy to the number of nights between a pair of sets. Astronomic latitude determinations were computed for the mean of two sets. There are 166 different values. Homogeneity of variances between the four classes could not be disproved at the 0.05 test level. The accuracy of a pair of latitude sets is not dependent on the time span between the two sets.

(5) Table 34 presents the relationship of astronomic latitude accuracy to the number of sets meaned in a night. Homogeneity of variances between the 12 classes can be discredited at the 0.05 test level. There is accuracy improvement from one set per night to four sets per night. No significant improvement can be realized by observing more than four sets per night.

p. Astronomic Longitude Accuracy Correlation.

(1) Correlation of astronomic longitude accuracy of a set with four parameters was investigated. Parameters are set precision, number of stars per set, number of nights between two sets, and number of sets meaned per night. Astronomic longitude data (329 sets) observed from 3 August to 12 November 1977 at station THEODORE were used for this analysis. Residuals of each set, pair of sets, or combination of sets were computed as a deviation from the standard. Accuracy figures were determined from these residuals. Homogeneity of variances was tested using Bartlett's test.

(2) Table 35 shows the relationship of accuracy to precision for one set of astronomic longitude. Homogeneity of variances between the six classes could not be discredited at the 0.05 probability test level. Generally, as the precision improves, accuracy improves. The ratio of accuracy to precision varies from 3:1 to 9:1. No fixed ratio can be stated from the data in hand.

(3) Table 36 displays the relationship of accuracy to number of acceptable stars in a set of astronomic longitude. At the 0.05 probability test level, homogeneity of variances between the six classes could not be refuted. No significant change in set accuracy is apparent as one varies the number of stars in a set from 7 to 10. Use of only six stars per set degrades the accuracy too much.

(4) Table 37 shows the relationship of astronomic longitude accuracy to the number of nights between a pair of sets. Astronomic longitude determinations were computed for the mean of two sets. There are 161 different values. Homogeneity of variances between the four classes could not be disproved at the 0.05 test level.

(5) Table 38 displays the relationship of astronomic longitude accuracy to the number of sets meaned in a night. Homogeneity of variances between the 12 classes could not be discredited at the 0.05 probability test level. There appears to be no significant accuracy improvement from use of 2 sets per night to 12 sets per night. Use of only one set per night degrades the accuracy too much.

q. Analysis of Multiple Observers and/or Instruments for Astronomic Latitude Observations. Table 39 lists various accuracy standard errors achieved by combining results of multiple observers and/or instruments. Using only one instrument, a slight accuracy improvement results by using two observers instead of one observer. Use of two different instruments by two different observers over five to seven nights improves the FO accuracy term by 40 percent from using only one instrument and one observer on two nights. The astronomic latitude accuracy improvement factor appears to be a mixture of instruments and observers over a time span of at least five nights.

r. Analysis of Multiple Observers and/or Instruments for Astronomic Longitude Observations. Table 40 lists several accuracy standard errors achieved by combining results of multiple observers and/or instruments. Using only one instrument, a 16 percent accuracy improvement is realized by using two different observers instead of one observer. The use of two different observers with two different instruments over five to six nights improves the accuracy figure by 44 percent as compared to the use of only one instrument and one observer on two to four nights. The overall astronomic longitude accuracy improvement factor seems to be a mixture of multiple observers and multiple instruments over five to six nights. After application of corrections for personal equations to FO results, the improvement in accuracy is 40 percent. Each of the 13 observer's personal equations were based on observations only at 1 reference station during a limited time frame, though.

s. Astronomic Latitude Star Pair Analysis.

(1) Investigation of star pair residuals of astronomic latitude as a function of the average zenith distance of the star pair was conducted. Figure 13 displays residuals of 1,139 star pairs from the standard astronomic latitude versus absolute zenith distance. Table 41 presents the data in five groups of zenith distance for each of three circle settings and for all three circle settings combined. Bartlett's test was employed to test for homogeneity of the five group variances. Table 42 lists the statistical information for each circle setting and for all three circle settings. Each of the statistic $\underline{M}$ values is less than the tabular value at the 0.05 probability test level. Hence, homogeneity of the five group variances cannot be refuted for each circle setting and for all three circle settings. Variance of astronomic latitude star pairs is not a function of the average zenith distance of the star pair.

(2) Least-squares straight line fits were computed for several subsets of the astronomic latitude star pair data. The seven subsets included four distinct time frames and three vertical circle settings, 0°, 60°, and 120°. None of the slopes of the straight line fits is significant at the 0.05 test level. The value of astronomic latitude is not a function of the average zenith distance of a star pair.

t. Analysis of Astronomic Latitude Results Versus Circle Settings. The astronomic latitude data was separated into several subsets. These included vertical circle index settings of 0°, 60°, and 120° and a comparison of Circle Left observations with Circle Right observations. Table 43 lists the pertinent statistical information by instrument and for all three instruments. No significant differences in the weighted mean latitude value can be detected between Circle Left and Circle Right observations for any of the three instruments. No significant differences in the weighted mean latitude value between any of the three vertical circle index settings are apparent for any of the three instruments.

6. PROBLEM AREA

a. The mean width of contact strip for theodolite Wild T-4 120741 was determined twice in 1977 before a different micrometer was installed. The difference of 0.439 between the two determinations is excessive. The method of determination for both values was the same. Previous determinations from February 1973 to August 1975 along with the 77 values are tabulated below in chronological order.

Date	Value
1 Feb 73	1.193
25 Aug 73	1.179
14 Aug 74	0.698
3 Sep 74	1.118
12 Mar 75	0.733
21 Aug 75	0.737
29 Jul 77	1.224
9 Sep 77	0.785

These values are grouped about two means, 1.179 and 0.738. Standard errors of these two means are ±0.022 and ±0.018, respectively.

b. The effect of the change in mean width of contact strips on the astronomic longitude determination was investigated using the two 1977 values. The same lost motion value of +0.06568 and equatorial values were used in both determinations. The results are summarized in the following table:

Observer	No. of Sets	Dates Observed	Longitude Result		Difference
Austin	8	3, 5, 9 Aug 77	54".91*	55".34**	0".43
Salvermoser	8	10, 12, 13 Aug 77	54".56	55".00	0"44
White	3	14 Aug 77	54".66	55".10	0".44
Zeigler	8	30 Aug, 1 Sep 77	54".16	54".60	0".44

*Mean width of contact strips = 0.77531
**Mean width of contact strips = 1.22415

An increase of 0.44884 in the mean width of contact strips increased (shifted west) the longitude by 0".44 on the average. Longitude results using a value of 1.22415 for the mean width of contact strips were used in the report. On 15 September 1977, the micrometer drum was replaced on instrument Wild T-4 120741. Only the above 4 observers out of 14 observers used the old micrometer so no additional comparisons can be made.

7. CONCLUSIONS

a. Final estimated accuracy figures for both FO and MFO astronomic position determinations are as follows:

	Latitude		Longitude	
Type	Accuracy Std. Error	Degrees of Freedom	Accuracy Std. Error	Degrees of Freedom
First-Order	$\pm 0\overset{''}{.}15$	37	$\pm 0\overset{''}{.}25 \sec \sigma$	36
Modified First-Order	$\pm 0\overset{''}{.}19$	78	$\pm 0\overset{''}{.}28 \sec \sigma$	78

At a latitude of 45°, the longitude accuracies equate to $\pm 0\overset{''}{.}35$ (one sigma) for FO and $\pm 0\overset{''}{.}40$ (one sigma) for MFO. These figures represent the accuracy of an astronomic position determination made by a qualified and experienced observer using one Wild T-4 theodolite. Longitude accuracy figures are based on results not corrected for personal equations.

b. No significant observer's personal equation was found in the astronomic latitude data sample. Thirteen of 14 observers have significant personal equations in the astronomic longitude data samples.

c. None of the three Wild T-4 theodolites contain any significant astronomic latitude or longitude bias from the standard. However, significant "relative" bias is present between results for instruments Wild T-4 120740 and 120741.

d. Significant additional variation in the astronomic latitude and longitude set values exists because of between FO, between MFO, and between night variances as compared to the within FO, within MFO, and within night variances.

e. Multiple regression analysis of astronomic latitude set data produced no significant correlation of any of the 11 variables with the astronomic latitude value of a set. Three independent variables are weakly correlated with the astronomic longitude of a set. They are azimuth correction, Greenwich Civil day, and wind azimuth.

f. Variance of astronomic latitude set data is not a function of the time of night, time since sunset, nor time of year (August through November).

g. Variance of astronomic longitude set data is not a function of the time of night, nor the time since sunset. However, variance of astronomic longitude set data with time of year was found to be significant. Since different observers were observing during the 4-month time period, this variance correlation is masked in the personal equations.

h. Variance of astronomic longitude set data for instrument Wild T-4 120737 is a function of the temperature. As the temperature decreases, the variance of the data increases. The astronomic longitude of a set is a function of the temperature of a set only for instrument Wild T-4 120741. The value of the astronomic longitude of a set shifts west as the temperature decreases.

i. Variances of astronomic longitude set data for instruments Wild T-4 120740 and Wild T-4 120741 are a function of the wind azimuth.

j. There is no significant algebraic bias in the astronomic longitude of a set when azimuth stars are included in the computation of a set.

k. There is significant improvement in the accuracy of an astronomic latitude set when the precision of the set improves. The best accuracy of a set is obtained with eight acceptable stars in a set and the worst with six acceptable stars in a set. The accuracy of a determination of astronomic latitude improves from use of only one set per night to four sets per night. No significant improvement is realized by observing more than four sets per night.

l. The accuracy of an astronomic longitude set improves as the precision improves. There is no significant change in the set accuracy as one varies the acceptable number of stars in a set from 7 to 10. Use of only six stars per set degrades the accuracy of the set. There is no significant improvement in the accuracy of a determination of astronomic longitude from use of 2 sets per night to 12 sets per night. Use of only one set per night degrades the accuracy.

m. The astronomic latitude accuracy of a determination can be significantly improved by using two different instruments and two different observers with observations collected over five to seven nights.

n. The accuracy of an astronomic longitude determination can be significantly improved by use of two different observers using two different instruments with observations collected over five to six nights.

o. Variance of the value of astronomic latitude of a star pair is not a function of the average zenith distance of the star pair. The astronomic latitude is not a function of the average zenith distance of a star pair.

p. There is no significant difference in the astronomic latitude value between Circle Left and Circle Right observations for each of the three instruments. There are no significant differences in the astronomic latitude value between any of the three vertical circle index settings for each of the three instruments.

8. RECOMMENDATIONS

a. General. Three categories of recommended actions pertain to standard first-order positions; superior astronomic positions; and improvement of astronomic positions. Each of these categories is broken down into several independent action items.

b. Standard First-Order Positions. (For ordinary astronomic position requirements.)

(1) Use FK4 stars mainly and accept FK4 supplement stars not to exceed 50 percent of total stars/set.

(2) Determine instrument calibration values periodically.

(3) Read and record temperature near hanging level vial during each set of longitude observations.

(4) Observe on either of these foundations, with a separate observer platform.

(a) Cinder block pier on concrete base.
(b) Well-anchored wooden tripod (steel stakes with dimples).

(5) Use two observers.

(6) Use oscilloscopes for radio-clock comparisons. Record clock synchronizations with a scope camera if availabe or draw a diagram of the oscilloscope display. Prints of radio signals through the Datametrics are required for radio-clock comparisons.

(7) At least 3 revolutions of micrometer drum (27 readings for both "in" and "out" track) will be done for each star tracking.

(8) Use of prism attachments for the hanging level is mandatory for a two-man astro party.

(9) Each astro observer will be certified once each year for either/both astronomic latitude and longitude observations. To be certified, the residual of his/her FO determination from the standard for the reference station will not exceed $\pm 0''.25$ for latitude and $\pm 0''.41$ sec σ for longitude. These figures are based on a 90-percent confidence level using standard errors of $\pm 0''.15$ and $\pm 0''25$ sec σ for astronomic latitude and longitude, respectively.

c. Superior Astronomic Positions. (Very best possible within reason using present equipment and procedures. In addition to procedures for standard first-order observations, the following additional procedures will be adhered to.)

(1) Use a. least two observers and two instruments.

(2) Establish and apply personal equations. Observe three nights at reference station before and after field station(s) with two instruments.

(3) Observe a minimum of six nights.

(4) Observe at least 24 sets of latitude and 24 sets of longitude. (12 sets per observer, 6 sets/instrument/observer.)

(5) Alternate instruments on each night.

(6) Each observer will observe at least 2 sets per night, preferably 3 sets per night.

(7) Use three-man teams (one man to read level vial bubbles and vertical circle).

(8) Establish reference stations at F. E. Warren AFB, WSMR, Vandenberg AFB, and other appropriate locations. These reference stations should be tied to the U.S. Naval Observatory (USNO), Washington, D.C., or USNO, Richmond, Florida. Observers will have to reestablish their personal equations at frequent intervals at a reference station.

(9) Record ambient temperature for each star observation for field checking of excessive temperature gradients.

d. Improvement of Astronomic Positions

(1) Modify Datametrics timing system to record either or both a "make" and "break."

(2) Obtain a faster printer for the Datametrics timing system. Obtain a dual-recording capability such as cassette and hard copy.

(3) Use two Horrebow-Talcott levels on the vertical circle level mount.

(4) Obtain tritium illumination for level vials to eliminate the need for a flashlight.

(5) Substitute inclinometers (electronic levels) or mercury levels for level vials and test for significant improvement.

(6) Insulate level vials and other heat sensitive instrument parts to prevent temperature gradients.

(7) Attach an insulated lightweight handle to the telescope tube.

(8) Obtain lightweight star filters and manufacture a dummy filter to equalize weight on the telescope tube when not using a star filter.

(9) Acquire and test a motor-driven micrometer on a Wild T-4 theodolite similar to the one manufactured for the Askania AP70 astronomic transit to reduce personal equation.

(10) Investigate the problem of the time difference between the Datametrics and the oscilloscope display during radio-chronometer comparisons.

(11) Develop and test new zenith distance star pair method for astronomic latitude. This method uses techniques from both the Sterneck and Horrebow-Talcott methods.

(12) Acquire and test an Askania AP 70 transit instrument and a Zeiss Jena THEO-002 theodolite.

(13) Support refractometer development with equipment and/or manpower as necessary.

(14) Support testing of sensor array (charge coupled device) modification to the Wild T-4 theodolite.

(15) Support investigation of possible error sources in the Automated Astronomic Positioning System (AAPS) on a limited basis. One test proposed is level sensitivity on the Frank J. Seiler Research Laboratory's (FJSRLs) Stable Table at the Air Force Academy, Colorado.

(16) Test astronomic longitude star pair observing techniques using stars with small "A" factors (less than $|0.2|$).

REFERENCES

1. Department of the Army Technical Manual 5-442, August 1970, Precise Astronomic Surveys.

2. Hamilton, W. C., Statistics in Physical Science, 1964.

Table 1. Theodore Astronomic Latitude Results by Observer

THEODORE ASTRONOMIC LATITUDE RESULTS BY OBSERVER
STANDARD POSITION= 41 8 5.02 N

OBSERVER	NR OF SETS OBS	NR OF SETS ACC	NR OF STARS OBS	NR OF STARS ACC	MEAN VALUE ARC SECONDS	RESIDUAL FROM STD ARC SECONDS	STD ERROR OF MEAN ARC SECONDS	STD ERROR OF ONE SET ARC SECONDS	TIME PERIOD YRGCD-YRGCD
AUSTIN	21	21	170	168	4.92	-0.10	0.059	0.27	77216-77227
WHITE	21	21	171	168	4.95	-0.07	0.053	0.24	77216-77227
SALVERMOSER	21	21	168	168	5.02	0.00	0.056	0.26	77216-77227
CADDESS	22	22	175	171	5.01	-0.01	0.054	0.26	77232-77243
ZEIGLER	28	28	223	221	5.03	0.01	0.046	0.24	77232-77243
ROBERTS	25	25	201	197	5.06	0.04	0.045	0.22	77257-77270
PERELKA	25	25	200	197	5.03	0.01	0.054	0.27	77257-77266
PHILLIPS	25	25	203	195	4.92	-0.10	0.064	0.32	77257-77266
FINCH	25	24	200	190	5.08	0.06	0.058	0.28	77285-77292
ZELLERS	25	24	201	190	5.06	0.04	0.051	0.25	77285-77292
BARTON	25	24	200	185	5.02	0.00	0.055	0.27	77285-77292
BERNARD	27	27	217	215	5.12	0.10	0.055	0.29	77293-77308
WOODARD	27	27	217	206	5.08	0.06	0.061	0.32	77293-77308
COURBIS	24	24	194	191	4.98	-0.04	0.061	0.30	77306-77320
TOTALS	341	338	2740	2662					

WEIGHTED MEAN= 5.02
STANDARD ERROR OF A SET= 0.296
STANDARD ERROR OF THE MEAN = 0.016

Table 2. Theodore Astronomic Longitude Results by Observer

THEODORE ASTRONOMIC LONGITUDE RESULTS BY OBSERVER
STANDARD POSITION= 104 51 55.34 W

OBSERVER	NR OF SETS OBS	NR OF SETS ACC	NR OF STARS OBS	NR OF STARS ACC	MEAN VALUE ARC SECONDS	RESIDUAL FROM STD ARC SECONDS	STD ERROR OF MEAN ARC SECONDS	STD ERROR OF ONE SET ARC SECONDS	TIME PERIOD YRGCD-YRGCD
AUSTIN	20	19	170	160	55.48	0.14	0.034	0.15	77215-77226
WHITE	20	20	181	176	55.16	-0.18	0.032	0.14	77215-77226
SALVERMOSER	16	14	139	123	55.27	-0.07	0.048	0.18	77217-77226
CADDESS	21	21	177	170	55.51	0.17	0.037	0.17	77232-77244
ZEIGLER	25	25	208	204	55.00	-0.34	0.036	0.18	77232-77244
PERELKA	26	23	217	181	55.14	-0.20	0.043	0.20	77257-77267
PHILLIPS	26	26	223	214	55.06	-0.28	0.040	0.20	77257-77267
ROBERTS	26	26	217	213	55.18	-0.16	0.034	0.17	77257-77270
FINCH	26	26	219	212	55.46	0.12	0.036	0.19	77285-77292
ZELLERS	26	24	225	203	55.72	0.38	0.034	0.17	77285-77292
BARTON	26	22	224	181	55.20	-0.14	0.037	0.17	77285-77292
BERNARD	26	26	215	208	55.19	-0.15	0.037	0.19	77293-77308
WOODARD	26	26	218	213	55.75	0.41	0.042	0.22	77293-77308
COURBIS	24	24	199	191	55.63	0.29	0.035	0.17	77306-77316
TOTALS	334	322	2832	2649					

WEIGHTED MEAN=55.34
STANDARD ERROR OF A SET= 1.223
STANDARD ERROR OF THE MEAN = 0.068

Table 3. Theodore Astronomic Latitude Results by Instrument

Instrument Wild T-4	Latitude Parameters			
	Mean Value	Difference From Std.	Std. Error of Mean	No. of Sets
120737	04″.97	-0″.05	±0″.033	118
120740	05″.05	+0″.03	±0″.042	118
120741	05″.06	+0″.04	±0″.045	102

Table 4. Theodore Astronomic Longitude Results By Instrument

Instrument Wild T-4	Longitude Parameters			
	Mean Value	Difference From Std.	Std. Error of Mean	No. of Sets
120737	55″.30	-0″.04	±0″.068	107
120740	55″.50	+0″.16	±0″.080	118
120741	55″.12	-0″.22	±0″.087	99

Table 5. Final First-Order Astronomic Latitude Results at Station Theodore

ASTRONOMIC LATITUDE SECONDS	RESIDUAL FROM STD SECONDS	STD ERROR OF FO SECONDS	SETS OBS	SETS ACC	STARS OBS	STARS ACC	YRGCD	INSTRUMENT WILD T4	OBSERVER
4.85	-0.17	0.072	9	9	73	72	77216	120741	AUSTIN
•	•	•					77217	120741	AUSTIN
•	•	•					77218	120741	AUSTIN
•	•	•					77221	120741	AUSTIN
4.87	-0.15	0.104	8	8	65	65	77224	120740	AUSTIN
•	•	•					77225	120740	AUSTIN
•	•	•					77226	120740	AUSTIN
5.05	+0.03	0.081	9	9	73	71	77216	120740	WHITE
•	•	•					77217	120740	WHITE
•	•	•					77218	120740	WHITE
•	•	•					77221	120740	WHITE
4.81	-0.21	0.090	8	8	66	65	77224	120737	WHITE
•	•	•					77225	120737	WHITE
•	•	•					77226	120737	WHITE
5.04	+0.02	0.079	9	9	72	72	77216	120737	SALVERMOSER
•	•	•					77217	120737	SALVERMOSER
•	•	•					77218	120737	SALVERMOSER
•	•	•					77221	120737	SALVERMOSER
5.03	+0.01	0.101	8	8	64	64	77224	120741	SALVERMOSER
•	•	•					77225	120741	SALVERMOSER
•	•	•					77226	120741	SALVERMOSER
5.00	-0.02	0.071	12	12	95	95	77232	120740	CADDESS
•	•	•					77235	120740	CADDESS
•	•	•					77236	120740	CADDESS
•	•	•					77243	120740	CADDESS
5.03	+0.01	0.084	10	10	80	76	77237	120737	CADDESS
•	•	•					77238	120737	CADDESS
•	•	•					77242	120737	CADDESS
5.04	+0.02	0.076	12	12	95	94	77232	120737	ZEIGLER
•	•	•					77233	120737	ZEIGLER
•	•	•					77235	120737	ZEIGLER
•	•	•					77236	120737	ZEIGLER
4.92	-0.10	0.081	8	8	64	63	77237	120740	ZEIGLER
•	•	•					77238	120740	ZEIGLER
•	•	•					77241	120740	ZEIGLER
5.13	+0.11	0.080	8	8	64	64	77242	120741	ZEIGLER
•	•	•					77243	120741	ZEIGLER
4.80	-0.22	0.089	9	9	72	71	77257	120737	PERELKA
•	•	•					77258	120737	PERELKA
•	•	•					77260	120737	PERELKA
4.89	-0.13	0.084	8	8	64	64	77261	120740	PERELKA
•	•	•					77262	120740	PERELKA
5.44	+0.42	0.091	8	8	64	62	77263	120741	PERELKA
•	•	•					77264	120741	PERELKA
•	•	•					77265	120741	PERELKA
•	•	•					77266	120741	PERELKA
4.92	-0.10	0.101	9	9	73	72	77257	120741	PHILLIPS
•	•	•					77258	120741	PHILLIPS
•	•	•					77260	120741	PHILLIPS
4.86	-0.16	0.120	8	8	64	61	77261	120737	PHILLIPS
•	•	•					77262	120737	PHILLIPS
4.97	-0.05	0.114	8	8	66	62	77263	120740	PHILLIPS
•	•	•					77264	120740	PHILLIPS
•	•	•					77265	120740	PHILLIPS
•	•	•					77266	120740	PHILLIPS

Table 5. Final First-Order Astronomic Latitude Results at Station Theodore-Continued

ASTRONOMIC LATITUDE SECONDS	RESIDUAL FROM STD SECONDS	STD ERROR OF FO SECONDS	SETS OBS	SETS ACC	STARS OBS	STARS ACC	YRGCD	INSTRUMENT WILD T4	OBSERVER
5.04	+0.02	0.072	9	9	73	71	77257	120740	ROBERTS
•	•	•					77260	120740	ROBERTS
•	•	•					77270	120740	ROBERTS
5.14	+0.12	0.074	8	8	64	64	77261	120741	ROBERTS
•	•	•					77262	120741	ROBERTS
5.00	-0.02	0.088	8	8	64	62	77263	120737	ROBERTS
•	•	•					77264	120737	ROBERTS
•	•	•					77265	120737	ROBERTS
•	•	•					77266	120737	ROBERTS
5.05	+0.03	0.104	9	9	72	68	77285	120740	BARTON
•	•	•					77286	120740	BARTON
•	•	•					77287	120740	BARTON
4.97	-0.05	0.096	8	7	64	55	77289	120741	BARTON
•	•	•					77290	120741	BARTON
5.03	+0.01	0.083	8	8	64	62	77291	120737	BARTON
•	•	•					77292	120737	BARTON
4.80	-0.22	0.120	9	8	71	61	77285	120737	FINCH
•	•	•					77286	120737	FINCH
•	•	•					77287	120737	FINCH
5.41	+0.39	0.086	8	8	65	65	77289	120740	FINCH
•	•	•					77290	120740	FINCH
5.01	-0.01	0.076	8	8	64	64	77291	120741	FINCH
•	•	•					77292	120741	FINCH
5.06	+0.04	0.084	9	8	72	64	77285	120741	ZELLERS
•	•	•					77286	120741	ZELLERS
•	•	•					77287	120741	ZELLERS
5.01	-0.01	0.090	8	8	65	64	77289	120737	ZELLERS
•	•	•					77290	120737	ZELLERS
5.12	+0.10	0.090	8	8	64	62	77291	120740	ZELLERS
•	•	•					77292	120740	ZELLERS
5.33	+0.31	0.091	10	10	80	80	77293	120740	BERNARD
•	•	•					77299	120740	BERNARD
•	•	•					77300	120740	BERNARD
5.11	+0.09	0.096	9	9	72	71	77301	120741	BERNARD
•	•	•					77302	120741	BERNARD
•	•	•					77306	120741	BERNARD
4.88	-0.14	0.094	8	8	65	64	77307	120737	BERNARD
•	•	•					77308	120737	BERNARD
5.02	0.00	0.095	10	10	80	76	77293	120737	WOODARD
•	•	•					77299	120737	WOODARD
•	•	•					77300	120737	WOODARD
5.02	0.00	0.106	9	9	72	70	77301	120740	WOODARD
•	•	•					77302	120740	WOODARD
•	•	•					77306	120740	WOODARD
5.21	+0.19	0.118	8	8	65	60	77307	120741	WOODARD
•	•	•					77308	120741	WOODARD
5.05	+0.03	0.101	8	8	64	62	77306	120737	COURBIS
•	•	•					77309	120737	COURBIS
4.98	-0.04	0.093	8	8	64	63	77307	120740	COURBIS
•	•	•					77308	120740	COURBIS
4.91	-0.11	0.119	8	8	66	66	77314	120741	COURBIS
•	•	•					77315	120741	COURBIS
•	•	•					77320	120741	COURBIS

Table 6. Final Modified First-Order Astronomic Latitude Results at Station Theodore

ASTRONOMIC LATITUDE SECONDS	RESIDUAL FROM STD SECONDS	STD ERROR OF MEO SECONDS	SETS OBS	SETS ACC	STARS OBS	STARS ACC	YRGCD	INSTRUMENT WILD T4	OBSERVER
4.92	−0.10	0.105	4	4	34	34	77216	120741	AUSTIN
•	•	•					77217	120741	AUSTIN
4.75	−0.27	0.107	4	4	32	31	77221	120741	AUSTIN
4.55	−0.47	0.156	4	4	32	32	77224	120740	AUSTIN
5.18	+0.16	0.117	4	4	33	33	77225	120740	AUSTIN
•	•	•					77226	120740	AUSTIN
5.21	+0.19	0.155	4	4	32	31	77227	120737	AUSTIN
4.98	−0.04	0.097	4	4	34	33	77216	120740	WHITE
•	•	•					77217	120740	WHITE
5.04	+0.02	0.122	4	4	32	32	77221	120740	WHITE
4.70	−0.32	0.108	4	4	32	32	77224	120737	WHITE
4.92	−0.10	0.141	4	4	34	33	77225	120737	WHITE
•	•	•					77226	120737	WHITE
5.04	+0.02	0.102	4	4	32	32	77227	120741	WHITE
5.11	+0.09	0.086	4	4	32	32	77216	120737	SALVERMOSER
•	•	•					77217	120737	SALVERMOSER
4.91	−0.11	0.119	4	4	32	32	77221	120737	SALVERMOSER
5.17	+0.15	0.165	4	4	32	32	77224	120741	SALVERMOSER
4.89	−0.13	0.113	4	4	32	32	77225	120741	SALVERMOSER
•	•	•					77226	120741	SALVERMOSER
4.95	−0.07	0.128	4	4	32	32	77227	120740	SALVERMOSER
4.88	−0.14	0.137	4	4	32	32	77232	120740	CADDESS
5.06	+0.04	0.103	4	4	31	31	77235	120740	CADDESS
•	•	•					77236	120740	CADDESS
5.12	+0.10	0.155	4	4	32	30	77237	120737	CADDESS
5.01	−0.01	0.122	4	4	32	31	77242	120737	CADDESS
5.06	+0.04	0.128	4	4	32	32	77243	120740	CADDESS
4.98	−0.04	0.166	4	4	32	31	77232	120737	ZEIGLER
5.07	+0.05	0.100	4	4	32	32	77233	120737	ZEIGLER
5.07	+0.05	0.128	4	4	31	31	77235	120737	ZEIGLER
•	•	•					77236	120737	ZEIGLER
4.92	−0.10	0.088	4	4	32	31	77237	120740	ZEIGLER
4.93	−0.09	0.135	4	4	32	32	77238	120740	ZEIGLER
•	•	•					77241	120740	ZEIGLER
5.14	+0.12	0.094	4	4	32	32	77242	120741	ZEIGLER
5.12	+0.10	0.131	4	4	32	32	77243	120741	ZEIGLER
4.98	−0.04	0.103	4	4	32	32	77258	120737	PERELKA
4.57	−0.45	0.149	4	4	32	31	77260	120737	PERELKA
4.86	−0.16	0.152	3	3	24	24	77261	120740	PERELKA
4.92	−0.10	0.100	5	5	40	40	77262	120740	PERELKA
5.53	+0.51	0.132	4	4	32	31	77263	120741	PERELKA
5.35	+0.33	0.124	4	4	32	31	77264	120741	PERELKA
•	•	•					77265	120741	PERELKA
•	•	•					77266	120741	PERELKA
5.15	+0.13	0.152	4	4	33	33	77258	120741	PHILLIPS
4.70	−0.32	0.142	4	4	32	31	77260	120741	PHILLIPS
4.78	−0.24	0.154	5	5	40	40	77262	120737	PHILLIPS
5.08	+0.06	0.133	4	4	32	31	77263	120740	PHILLIPS
4.86	−0.16	0.186	4	4	34	31	77264	120740	PHILLIPS
•	•	•					77265	120740	PHILLIPS
•	•	•					77266	120740	PHILLIPS

Table 6. Final Modified First-Order Astronomic Latitude Results at Station Theodore-Continued

ASTRONOMIC LATITUDE SECONDS	RESIDUAL FROM STD SECONDS	STD ERROR OF MEO SECONDS	SETS OBS	SETS ACC	STARS OBS	STARS ACC	YRGCD	INSTRUMENT WILD T4	OBSERVER
5.05	+0.03	0.122	4	4	32	32	77260	120740	ROBERTS
5.26	+0.24	0.108	3	3	24	24	77261	120741	ROBERTS
5.07	+0.05	0.099	5	5	40	40	77262	120741	ROBERTS
4.97	-0.05	0.149	4	[illegible]	32	31	77263	120737	ROBERTS
5.02	0.00	0.095	4	4	32	31	77264	120737	ROBERTS
.	.	.					77265	120737	ROBERTS
.	.	.					77266	120737	ROBERTS
5.10	+0.08	0.096	4	4	33	31	77270	120740	ROBERTS
5.11	+0.09	0.171	4	4	32	32	77286	120740	BARTON
5.02	0.00	0.152	4	4	32	29	77287	120740	BARTON
4.90	-0.12	0.128	4	4	32	32	77290	120741	BARTON
4.91	-0.11	0.105	4	4	32	31	77291	120737	BARTON
5.14	+0.12	0.128	4	4	32	31	77292	120737	BARTON
4.60	-0.42	0.191	4	4	32	30	77286	120737	FINCH
5.00	-0.02	0.143	4	4	32	31	77287	120737	FINCH
5.52	+0.50	0.135	4	4	33	33	77289	120740	FINCH
5.30	+0.28	0.105	4	4	32	32	77290	120740	FINCH
5.15	+0.13	0.073	4	4	32	32	77291	120741	FINCH
4.87	-0.15	0.129	4	4	32	32	77292	120741	FINCH
5.20	+0.18	0.131	4	4	32	32	77286	120741	ZELLERS
4.92	-0.10	0.103	4	4	32	32	77287	120741	ZELLERS
4.90	-0.12	0.116	4	4	33	32	77289	120737	ZELLERS
5.12	+0.10	0.136	4	4	32	32	77290	120737	ZELLERS
5.02	0.00	0.143	4	4	32	30	77291	120740	ZELLERS
5.21	+0.19	0.112	4	4	32	32	77292	120740	ZELLERS
5.08	+0.06	0.158	4	4	32	32	77299	120740	BERNARD
5.58	+0.56	0.114	4	4	32	32	77300	120740	BERNARD
5.06	+0.04	0.135	4	4	32	32	77301	120741	BERNARD
5.11	+0.09	0.149	4	4	32	31	77306	120741	BERNARD
5.10	+0.08	0.136	4	4	33	32	77307	120737	BERNARD
4.67	-0.35	0.120	4	4	32	32	77308	120737	BERNARD
4.98	-0.04	0.176	4	4	32	29	77299	120737	WOODARD
5.13	+0.11	0.141	4	4	32	31	77300	120737	WOODARD
5.17	+0.15	0.172	4	4	32	32	77301	120740	WOODARD
4.91	-0.11	0.157	4	4	32	30	77306	120740	WOODARD
5.30	+0.28	0.175	4	4	33	30	77307	120741	WOODARD
5.11	+0.09	0.159	4	4	32	30	77308	120741	WOODARD
5.01	-0.01	0.125	4	4	32	32	77306	120737	COURBIS
4.88	-0.14	0.146	4	4	32	32	77307	120740	COURBIS
5.07	+0.05	0.113	4	4	32	31	77308	120740	COURBIS
5.10	+0.08	0.163	4	4	32	30	77309	120737	COURBIS
5.08	+0.06	0.169	4	4	32	32	77314	120741	COURBIS
.	.	.					77320	120741	COURBIS
4.75	-0.27	0.166	4	4	34	34	77315	120741	COURBIS

Table 7. Final First-Order Astronomic Longitude Results at Station Theodore

ASTRONOMIC LONGITUDE SECONDS	RESIDUAL FROM STD SECONDS	STD ERROR OF FO SECONDS	SETS OBS	SETS ACC	STARS OBS	STARS ACC	YRGCD	INSTRUMENT WILD T4	OBSERVER
55.34	0.00	0.049	9	8	74	68	77215	120741	AUSTIN
•	•	•					77217	120741	AUSTIN
•	•	•					77221	120741	AUSTIN
55.67	+0.33	0.056	8	8	67	64	77222	120740	AUSTIN
•	•	•					77224	120740	AUSTIN
•	•	•					77225	120740	AUSTIN
55.23	-0.11	0.041	9	9	74	71	77215	120740	WHITE
•	•	•					77217	120740	WHITE
•	•	•					77221	120740	WHITE
55.11	-0.23	0.055	8	8	74	74	77222	120737	WHITE
•	•	•					77224	120737	WHITE
•	•	•					77225	120737	WHITE
55.00	-0.34	0.068	8	8	70	68	77222	120741	SALVERMOSER
•	•	•					77224	120741	SALVERMOSER
•	•	•					77225	120741	SALVERMOSER
55.58	+0.24	0.043	12	12	101	99	77232	120740	CADDESS
•	•	•					77236	120740	CADDESS
•	•	•					77244	120740	CADDESS
55.40	+0.06	0.065	9	9	76	71	77237	120737	CADDESS
•	•	•					77238	120737	CADDESS
•	•	•					77242	120737	CADDESS
55.16	-0.18	0.056	9	9	72	69	77232	120737	ZEIGLER
•	•	•					77233	120737	ZEIGLER
•	•	•					77236	120737	ZEIGLER
55.17	-0.17	0.056	8	8	69	69	77237	120740	ZEIGLER
•	•	•					77238	120740	ZEIGLER
•	•	•					77241	120740	ZEIGLER
54.60	-0.74	0.051	8	8	67	66	77242	120741	ZEIGLER
•	•	•					77244	120741	ZEIGLER
55.14	-0.20	0.058	10	8	84	61	77257	120737	PERELKA
•	•	•					77258	120737	PERELKA
•	•	•					77260	120737	PERELKA
•	•	•					77261	120737	PERELKA
55.36	+0.02	0.073	8	8	66	62	77261	120740	PERELKA
•	•	•					77262	120740	PERELKA
54.66	-0.68	0.071	8	7	67	59	77263	120741	PERELKA
•	•	•					77267	120741	PERELKA
54.96	-0.38	0.057	10	10	85	81	77257	120741	PHILLIPS
•	•	•					77258	120741	PHILLIPS
•	•	•					77260	120741	PHILLIPS
•	•	•					77261	120741	PHILLIPS
55.22	-0.12	0.070	8	8	70	68	77261	120737	PHILLIPS
•	•	•					77262	120737	PHILLIPS
54.96	-0.38	0.077	8	8	68	65	77263	120740	PHILLIPS
•	•	•					77267	120740	PHILLIPS
55.33	-0.01	0.052	10	10	84	83	77257	120740	ROBERTS
•	•	•					77260	120740	ROBERTS
•	•	•					77261	120740	ROBERTS
•	•	•					77270	120740	ROBERTS
54.94	-0.40	0.063	8	8	69	67	77261	120741	ROBERTS
•	•	•					77262	120741	ROBERTS
55.16	-0.18	0.050	8	8	64	63	77263	120737	ROBERTS
•	•	•					77267	120737	ROBERTS

Table 7. Final First-Order Astronomic Longitude Results
at Station Theodore-Continued

ASTRONOMIC LONGITUDE SECONDS	RESIDUAL FROM STD SECONDS	STD ERROR OF FO SECONDS	SETS OBS	SETS ACC	STARS OBS	STARS ACC	YRGCD	INSTRUMENT WILD T4	OBSERVER
55.46	+0.12	0.064	10	10	84	81	77285	120737	FINCH
•	•	•					77286	120737	FINCH
•	•	•					77287	120737	FINCH
55.64	+0.30	0.064	8	8	68	64	77288	120740	FINCH
•	•	•					77289	120740	FINCH
•	•	•					77290	120740	FINCH
55.26	-0.08	0.050	8	8	67	67	77291	120741	FINCH
•	•	•					77292	120741	FINCH
55.46	+0.12	0.039	10	9	85	74	77285	120741	ZELLERS
•	•	•					77286	120741	ZELLERS
•	•	•					77287	120741	ZELLERS
55.73	+0.39	0.060	8	7	72	62	77288	120737	ZELLERS
•	•	•					77289	120737	ZELLERS
•	•	•					77290	120737	ZELLERS
55.97	+0.63	0.062	8	8	68	67	77291	120740	ZELLERS
•	•	•					77292	120740	ZELLERS
55.35	+0.01	0.046	10	10	86	83	77285	120740	BARTON
•	•	•					77286	120740	BARTON
•	•	•					77287	120740	BARTON
55.08	-0.26	0.066	8	6	71	52	77288	120741	BARTON
•	•	•					77289	120741	BARTON
•	•	•					77290	120741	BARTON
54.87	-0.47	0.078	8	7	67	53	77291	120737	BARTON
•	•	•					77292	120737	BARTON
55.48	+0.14	0.066	10	10	81	76	77293	120740	BERNARD
•	•	•					77299	120740	BERNARD
•	•	•					77300	120740	BERNARD
54.99	-0.35	0.060	8	8	65	63	77301	120741	BERNARD
•	•	•					77302	120741	BERNARD
55.01	-0.33	0.047	8	8	69	69	77307	120737	BERNARD
•	•	•					77308	120737	BERNARD
55.64	+0.30	0.072	10	10	80	78	77293	120737	WOODARD
•	•	•					77299	120737	WOODARD
•	•	•					77300	120737	WOODARD
56.08	+0.74	0.065	8	8	67	66	77301	120740	WOODARD
•	•	•					77302	120740	WOODARD
55.51	+0.17	0.063	8	8	71	69	77307	120741	WOODARD
•	•	•					77308	120741	WOODARD
55.61	+0.27	0.077	8	8	66	61	77306	120737	COURBIS
•	•	•					77309	120737	COURBIS
55.65	+0.31	0.052	8	8	66	65	77307	120740	COURBIS
•	•	•					77308	120740	COURBIS
55.58	+0.24	0.051	8	8	67	65	77314	120741	COURBIS
•	•	•					77315	120741	COURBIS
•	•	•					77316	120741	COURBIS

Table 8. Final Modified First-Order Astronomic Longitude Results at Station Theodore

ASTRONOMIC LONGITUDE SECONDS	RESIDUAL FROM STD SECONDS	STD ERROR OF MEO SECONDS	SETS OBS	SETS ACC	STARS OBS	STARS ACC	YRGCD	INSTRUMENT WILD T4	OBSERVER
55.48	+0.14	0.075	4	4	33	32	77215	120741	AUSTIN
55.22	-0.12	0.059	4	4	36	36	77221	120741	AUSTIN
55.57	+0.23	0.069	4	4	32	31	77222	120740	AUSTIN
							77224	120740	AUSTIN
55.74	+0.40	0.085	4	4	35	33	77225	120740	AUSTIN
55.36	+0.02	0.054	3	3	29	28	77226	120737	AUSTIN
55.36	+0.02	0.059	4	4	32	31	77215	120740	WHITE
55.16	-0.18	0.053	4	4	36	35	77221	120740	WHITE
55.10	-0.24	0.091	4	4	35	35	77222	120737	WHITE
							77224	120737	WHITE
55.10	-0.24	0.067	4	4	39	39	77225	120737	WHITE
55.10	-0.24	0.075	3	3	33	31	77226	120741	WHITE
55.24	-0.10	0.057	4	4	35	35	77221	120737	SALVERMOSER
54.78	-0.56	0.089	4	4	33	31	77222	120741	SALVERMOSER
							77224	120741	SALVERMOSER
55.33	-0.01	0.090	4	3	37	29	77225	120741	SALVERMOSER
55.69	+0.35	0.086	3	3	29	29	77226	120740	SALVERMOSER
55.43	+0.09	0.063	4	4	34	33	77232	120740	CADDESS
55.63	+0.29	0.070	4	4	33	32	77236	120740	CADDESS
55.26	-0.08	0.077	4	4	35	32	77238	120737	CADDESS
55.52	+0.18	0.109	4	4	33	31	77242	120737	CADDESS
55.65	+0.31	0.083	4	4	34	34	77244	120740	CADDESS
55.24	-0.10	0.080	4	4	33	30	77232	120737	ZEIGLER
55.10	-0.24	0.094	4	4	31	31	77236	120737	ZEIGLER
55.09	-0.25	0.087	4	4	34	34	77238	120740	ZEIGLER
55.34	0.00	0.073	3	3	25	25	77241	120740	ZEIGLER
54.72	-0.62	0.069	4	4	33	33	77242	120741	ZEIGLER
54.48	-0.86	0.071	4	4	34	33	77244	120741	ZEIGLER
55.06	-0.28	0.076	4	4	33	30	77258	120737	PERELKA
55.17	-0.17	0.098	3	3	27	24	77260	120737	PERELKA
55.64	+0.30	0.092	4	4	33	31	77261	120740	PERELKA
55.08	-0.26	0.090	4	4	33	31	77262	120740	PERELKA
54.70	-0.64	0.103	3	3	25	25	77263	120741	PERELKA
54.63	-0.71	0.099	5	4	42	34	77267	120741	PERELKA
54.95	-0.39	0.086	4	4	33	32	77258	120741	PHILLIPS
54.91	-0.43	0.130	3	3	28	26	77260	120741	PHILLIPS
55.54	+0.20	0.086	4	4	33	31	77261	120737	PHILLIPS
54.95	-0.39	0.085	4	4	37	37	77262	120737	PHILLIPS
55.57	+0.23	0.055	3	3	26	25	77263	120740	PHILLIPS
54.55	-0.79	0.066	5	5	42	40	77267	120740	PHILLIPS
55.42	+0.08	0.061	3	3	27	27	77260	120740	ROBERTS
54.93	-0.41	0.092	4	4	33	32	77261	120741	ROBERTS
54.95	-0.39	0.088	4	4	36	35	77262	120741	ROBERTS
55.04	-0.30	0.086	3	3	22	21	77263	120737	ROBERTS
55.22	-0.12	0.060	5	5	42	42	77[illegible]67	120737	ROBERTS
55.15	-0.19	0.081	4	4	33	33	77270	120740	ROBERTS

Table 8. Final Modified First-Order Astronomic Longitude Results at Station Theodore-Continued

ASTRONOMIC LONGITUDE SECONDS	RESIDUAL FROM STD SECONDS	STD ERROR OF MEO SECONDS	SETS OBS	SETS ACC	STARS OBS	STARS ACC	YRGCD	INSTRUMENT WILD T4	OBSERVER
55.64	+0.30	0.087	4	4	34	32	77286	120737	FINCH
55.27	-0.07	0.095	4	4	33	32	77287	120737	FINCH
55.71	+0.37	0.113	4	4	35	32	77288	120740	FINCH
							77290	120740	FINCH
55.55	+0.21	0.062	4	4	33	32	77289	120740	FINCH
55.28	-0.06	0.065	4	4	33	33	77291	120741	FINCH
55.23	-0.11	0.076	4	4	34	34	77292	120741	FINCH
55.50	+0.16	0.061	4	4	34	33	77286	120741	ZELLERS
55.44	+0.10	0.053	4	4	33	33	77287	120741	ZELLERS
55.71	+0.37	0.067	4	3	39	31	77288	120737	ZELLERS
							77290	120737	ZELLERS
55.75	+0.41	0.100	4	4	33	31	77289	120737	ZELLERS
55.95	+0.61	0.064	4	4	34	34	77291	120740	ZELLERS
55.99	+0.65	0.109	4	4	34	33	77292	120740	ZELLERS
55.34	0.00	0.064	4	4	34	32	77286	120740	BARTON
55.30	-0.04	0.077	4	4	34	33	77287	120740	BARTON
54.96	-0.38	0.090	4	3	38	28	77288	120741	BARTON
							77290	120741	BARTON
55.22	-0.12	0.092	4	3	33	24	77289	120741	BARTON
54.50	-0.84	0.122	4	4	33	28	77291	120737	BARTON
55.00	-0.34	0.088	4	4	34	31	77292	120737	BARTON
55.67	+0.33	0.086	4	4	33	32	77299	120740	BERNARD
55.50	+0.16	0.107	4	4	31	28	77300	120740	BERNARD
55.10	-0.24	0.092	4	4	32	30	77301	120741	BERNARD
54.89	-0.45	0.076	4	4	33	33	77302	120741	BERNARD
54.95	-0.39	0.075	4	4	34	34	77307	120737	BERNARD
55.05	-0.29	0.055	4	4	35	35	77308	120737	BERNARD
55.52	+0.18	0.093	4	4	31	30	77299	120737	WOODARD
55.99	+0.65	0.110	4	4	32	31	77300	120737	WOODARD
56.06	+0.72	0.090	4	4	34	34	77301	120740	WOODARD
56.11	+0.77	0.094	4	4	33	32	77302	120740	WOODARD
55.46	+0.12	0.080	4	4	34	34	77307	120741	WOODARD
55.55	+0.21	0.097	4	4	37	35	77308	120741	WOODARD
55.75	+0.41	0.129	4	4	33	29	77306	120737	COURBIS
55.64	+0.30	0.075	4	4	33	32	77307	120740	COURBIS
55.65	+0.31	0.074	4	4	33	33	77308	120740	COURBIS
55.48	+0.14	0.085	4	4	33	32	77309	120737	COURBIS
55.49	+0.15	0.077	4	4	34	32	77314	120741	COURBIS
							77316	120741	COURBIS
55.66	+0.32	0.066	4	4	33	33	77315	120741	COURBIS

Table 9. FO Astronomic Latitude ANOVA

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between FOs	808.1	37	21.84	1.96
Within FOs	3212.3	288	11.15	
TOTAL	4020.4	325	12.37	

Table 10. MFO Astronomic Latitude ANOVA

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between MFOs	683.9	78	8.77	1.75
Within MFOs	1192.5	238	5.01	
TOTAL	1876.3	316	5.94	

Table 11. MFO (One Night) Astronomic Latitude ANOVA

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Nights	625.6	65	9.62	2.02
Within Nights	946.3	199	4.76	
TOTAL	1571.9	264	5.95	

Table 12. FO Astronomic Longitude ANOVA

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between FOs	9068.5	36	251.90	12.14
Within FOs	5686.4	274	20.75	
TOTAL	14754.9	310	47.60	

Table 13. MFO Astronomic Longitude ANOVA

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between MFOs	5977.6	78	76.64	8.99
Within MFOs	1916.1	225	8.52	
TOTAL	7893.7	303	26.05	

Table 14. MFO (One Night) Astronomic Longitude ANOVA

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Nights	5543.9	71	78.08	9.55
Within Nights	1685.9	206	8.18	
TOTAL	7229.8	277	26.10	

Table 15. Astronomic Latitude Set Residuals Grouped by Time of Night

Group	Local Time (MST) Hours	Instrument (Wild T4)							
		All Three		120737		120740		120741	
		Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets
1	17 to 20	122.5	89	89.4	29	184.1	32	95.2	28
2	20 to 22	95.3	126	121.8	42	84.4	45	84.4	39
3	22 to 24	94.9	71	107.1	26	98.4	25	84.5	20
4	0 to 2	83.4	42	86.9	17	81.4	13	95.7	12

Table 16. Bartlett's Test Statistics for Astronomic Latitude Set Residuals Grouped by Time of Night

Instrument Wild T4	Statistic M	Pooled Variance Meters^2	No. of Sets
All Three	2.92	100.7	338
120737	1.10	105.1	114
120740	6.86	114.9	115
120741	0.17	88.8	99

Table 17. Astronomic Latitude Set Residuals Grouped by Time Since Sunset

Group	Time Since Sunset Hours	Instrument (Wild T4)							
		All Three		120737		120740		120741	
		Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters	No. of Sets
1	0 to 2	118.5	93	102.4	30	166.4	33	89.9	30
2	2 to 4	100.1	126	97.5	44	112.1	45	94.2	37
3	4 to 6	86.1	56	131.6	19	77.4	21	54.5	16
4	6 to 8	90.7	60	93.4	24	77.7	18	110.7	18

Table 18. Bartlett's Test Statistics for Astronomic Latitude Set Residuals Grouped by Time Since Sunset

Instrument Wild T4	Statistic M	Pooled Variance Meters^2	No. of Sets
All Three	2.24	101.2	335
120737	0.76	103.3	117
120740	5.02	116.2	117
120741	2.03	89.7	101

Table 19. Astronomic Latitude Set Residuals Grouped by Time of Year

		Instrument (Wild T4)							
		All Three		120737		120740		120741	
Group	1977 Date	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets
1	4-15 Aug	82.8	63	82.8	21	106.1	21	67.9	21
2	20-31 Aug	80.0	50	82.0	22	80.0	20	97.0	8
3	14-27 Sep	112.8	75	112.4	25	91.6	25	143.8	25
4	12-19 Oct	100.5	72	117.4	24	131.6	25	58.2	23
5	20 Oct-16 Nov	116.6	78	116.1	26	159.4	27	80.5	25

Table 20. Bartlett's Test Statistics for Astronomic Latitude Set Residuals Grouped by Time of Year

Instrument Wild T4	Statistic M	Pooled Variance Meters^2	No. of Sets
All Three	3.68	100.7	338
120737	1.44	103.4	118
120740	3.52	116.3	118
120741	5.80	89.7	102

Table 21. Astronomic Longitude Set Residuals Grouped by Time of Night

Group	Local Time (MST) Hours	Instrument (Wild T4)							
		All Three		120737		120740		120741	
		Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets
1	18 to 20	97.8	55	55.4	15	148.7	22	81.3	18
2	20 to 22	115.9	88	78.1	32	121.5	30	165.6	26
3	22 to 24	89.1	115	82.9	38	79.4	42	112.9	35
4	0 to 2	62.5	58	61.0	20	65.9	21	67.8	17

Table 22. Bartlett's Test Statistics for Astronomic Longitude Set Residuals Grouped by Time of Night

Instrument Wild T4	Statistic M	Pooled Variance Meters^2	No. of Sets
All Three	6.40	93.2	324
120737	1.16	73.5	105
120740	5.00	101.1	115
120741	4.68	113.5	96

Table 23. Astronomic Longitude Set Residuals Grouped by Time Since Sunset

Group	Time Since Sunset Hours	Instrument (Wild T4)							
		All Three		120737		120740		120741	
		Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets
1	0 to 2	95.8	41	45.0	14	151.1	16	98.0	11
2	2 to 4	115.4	98	76.5	30	124.2	37	150.1	31
3	4 to 6	81.6	116	71.6	39	68.7	41	111.8	36
4	6 to 8	80.3	66	94.8	23	78.6	23	73.9	20

Table 24. Bartlett's Test Statistics for Astronomic Longitude Set Residuals Grouped by Time Since Sunset

Instrument Wild T4	Statistic M	Pooled Variance Meters^2	No. of Sets
All Three	4.06	93.5	321
120737	2.14	74.6	106
120740	5.46	99.3	117
120741	2.91	114.9	98

Table 25. Astronomic Longitude Set Residuals Grouped by Time of Year

		Instrument (Wild T4)							
		All Three		120737		120740		120741	
Group	1977 Date	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets
1	3-14 Aug	67.7	54	40.2	15	65.9	20	98.5	19
2	20 Aug-1 Sep	95.0	46	42.5	18	51.3	20	368.8	8
3	14-27 Sep	109.8	75	50.0	24	109.3	26	176.9	25
4	12-19 Oct	80.8	73	105.4	24	105.9	26	33.9	23
5	20 Oct-12 Nov	105.6	76	110.1	26	146.4	26	65.4	24

Table 26. Bartlett's Test Statistics for Astronomic Longitude Set Residuals Grouped by Time of Year

Instrument Wild T4	Statistic M	Pooled Variance Meters^2	No. of Sets
All Three	4.81	93.2	324
120737	9.78*	74.6	107
120740	7.10	99.7	118
120741	24.48*	115.4	99

* Significant at the 0.05 test level.

Table 27. Astronomic Longitude Set Residuals Grouped by Temperature

Group	Temperature Degrees F	Instrument (Wild T4)							
		All Three		120737		120740		120741	
		Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets
1	15 to 32	45.1	20	47.1	5	47.3	5	53.3	10
2	32 to 40	109.1	57	113.1	21	172.7	18	53.7	18
3	40 to 48	101.6	107	99.5	36	99.4	42	114.5	29
4	48 to 55	103.5	83	50.5	23	86.8	33	176.9	27
5	55 to 70	62.7	57	27.0	22	67.9	20	118.1	15

Table 28. Bartlett's Test Statistics for Astronomic Longitude Set Residuals Grouped by Temperature

Instrument Wild T4	Statistic M	Pooled Variance Meters^2	No. of Sets
All Three	9.46	93.2	324
120737	13.01*	75.7	102
120740	4.62	101.6	113
120741	8.79	115.4	99

* Significant at 0.05 probability test level.

Table 29. Astronomic Longitude Set Residuals Grouped by Wind Azimuth

Group	Wind Azimuth Degrees	Instrument (Wild T4)							
		All Three		120737		120740		120741	
		Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets	Variance Meters^2	No. of Sets
1	333 to 45	111.4	23	150.1	7	201.9	8	19.7	8
2	45 to 117	130.7	14	37.1	6	71.8	2	288.4	6
3	117 to 189	143.5	60	34.0	16	160.7	24	224.2	20
4	189 to 261	85.2	97	83.3	32	87.5	41	90.9	24
5	261 to 333	69.3	130	76.3	46	61.5	43	73.0	41

Table 30. Bartlett's Test Statistics for Astronomic Longitude Set Residuals Grouped by Wind Azimuth

Instrument Wild T4	Statistic M	Pooled Variance Meters^2	No. of Sets
All Three	13.12*	93.2	324
120737	6.68	74.6	107
120740	9.85*	100.0	116
120741	19.01*	115.4	99

* Significant at 0.05 probability test level.

Table 31. Astronomic Latitude Accuracy Versus Set Precision Values

Set Precision Standard Error	Set Accuracy Standard Error	Number of Sets
$\pm0''.13$	$\pm0''.26$	37
$\pm0''.19$	$\pm0''.28$	76
$\pm0''.24$	$\pm0''.33$	106
$\pm0''.30$	$\pm0''.33$	66
$\pm0''.37$	$\pm0''.40$	37
$\pm0''.44$	±0.43	16

Table 32. Astronomic Latitude Accuracy Versus Number of Stars Per Set

No. of Stars Per Set	Set Accuracy Standard Error	Number of Sets
6	$\pm0''.78$	5
7	$\pm0''.40$	46
8	$\pm0''.30$	275
9	$\pm0''.39$	10

Table 33. Astronomic Latitude Accuracy
Versus Number of Nights Between Two Sets

Day Interval	Accuracy Standard Error	Number of Set Pairs
1	$\pm 0''.24$	104
2 to 3	$\pm 0''.25$	26
4 to 6	$\pm 0''.25$	20
13 to 18	$\pm 0''.22$	16

Table 34. Astronomic Latitude Accuracy
Versus Number of Sets Meaned Per Night

No. of Sets Meaned Per Night	Accuracy Standard Error	Number of Observations
1	$\pm 0''.31$	46
2	$\pm 0''.27$	45
3	$\pm 0''.20$	40
4	$\pm 0''.17$	36
5	$\pm 0''.16$	30
6	$\pm 0''.15$	30
7	$\pm 0''.16$	24
8	$\pm 0''.13$	24
9	$\pm 0''.12$	16
10	$\pm 0''.13$	15
11	$\pm 0''.13$	15
12	$\pm 0''.12$	14

Table 35. Astronomic Longitude Accuracy
Versus Set Precision Values

Set Precision Standard Error	Set Accuracy Standard Error	Number of Sets
$\pm 0''.04$	$\pm 0''.35$	55
$\pm 0''.07$	$\pm 0''.42$	82
$\pm 0''.09$	$\pm 0''.44$	80
$\pm 0''.10$	$\pm 0''.50$	57
$\pm 0''.12$	$\pm 0''.41$	41
$\pm 0''.15$	$\pm 0''.50$	14

Table 36. Astronomic Longitude Accuracy
Versus Number of Stars Per Set

Number of Stars Per Set	Set Accuracy Standard Error	Number of Sets
6	±0".58	12
7	±0".40	46
8	±0".44	163
9	±0".42	75
10, 11, 12	±0".35	31

Table 37. Astronomic Longitude Accuracy
Versus Number of Nights Between Two Sets

Day Interval	Accuracy Standard Error	Number of Set Pairs
1	±0".37	88
2 to 3	±0".39	19
4 to 6	±0".27	35
13 to 18	±0".38	19

Table 38. Astronomic Longitude Accuracy
Versus Number of Sets Meaned Per Night

No. of Sets Meaned Per Night	Accuracy Standard Error	Number of Observations
1	±0".32	43
2	±0".25	41
3	±0".22	38
4	±0".22	37
5	±0".19	31
6	±0".19	30
7	±0".20	26
8	±0".21	26
9	±0".19	15
10	±0".21	12
11	±0".22	12
12	±0".20	12

Table 39. Astronomic Latitude Accuracy Improvement

No. of Instruments	No. of Observers	No. of Nights	Avg. No. of Sets	Avg. No. of Stars	Accuracy Std. Error	No. of Determinations
1	1	1	4	32	$\pm0''.19$(MFO)	78
1	1	2	9	68	$\pm0''.15$(FO)	38
1	2	3	11	84	$\pm0''.13$	29
2	2	3	11	84	$\pm0''.15$	28
2	2	5 to 7	22	170	$\pm0''.09$	13

Table 40. Astronomic Longitude Accuracy Improvement

No. of Instruments	No. of Observers	No. of Nights	Avg. No. of Sets	Avg. No. of Stars	Accuracy Standard Error	No. of Determinations
1	1	1	4	32	$\pm0''.28$ sec ϕ (MFO)	78
1	1	2 to 4	8	69	$\pm0''.25$ sec ϕ (FO)	37
1	2	3	11	86	$\pm0''.21$ sec ϕ	25
1	3	3 to 4	11	91	$\pm0''.18$ sec ϕ	26
2	2	2 to 3	8	66	$\pm0''.18$ sec ϕ	34
2	2	5 to 6	18	151	$\pm0''.14$ sec ϕ	13
1	1	2 to 4	8	69	$\pm0''.15$ sec ϕ (FO)*	37

* After applying corrections for personal equations.

Table 41. Astronomic Latitude Star Pair Residuals Grouped by Zenith Distance

Group	Absolute Zenith Distance Degrees	Circle Setting: All Three Variance Meters^2	All Three No. of Star Pairs	00 Degrees Variance Meters^2	00 Degrees No. of Star Pairs	60 Degrees Variance Meters^2	60 Degrees No. of Star Pairs	120 Degrees Variance Meters^2	120 Degrees No. of Star Pairs
1	0 to 5	324	124	399	38	288	42	310	44
2	5 to 10	340	157	340	44	415	55	281	58
3	10 to 20	318	278	304	105	316	85	344	88
4	20 to 30	320	278	293	100	350	101	323	77
5	30 to 40	299	302	293	119	360	108	228	75

Table 42. Bartlett's Test Statistics for Astronomic Latitude Star Pair Residuals Grouped by Zenith Distance

Circle Setting Degrees	Statistic M	Pooled Variance Meters^2	No. of Star Pairs
All Three	0.94	317	1139
00	1.83	311	406
60	2.03	348	391
120	3.76	299	342

Table 43. Astronomic Latitude Statistics Versus Circle Setting

Instrument Wild T4	Circle Setting	No. of Sets	Weighted Mean* Latitude	Std. Error of the Mean	Std. Error of a Set
All Three	00°	119	5".34	±0".030	±0".327
All Three	60°	113	5".32	±0".031	±0".327
All Three	120°	106	5".36	±0".030	±0".304
All Three	Left	173	5".34	±0".025	±0".327
All Three	Right	165	5".34	±0".024	±0".313
120737	00°	39	5".23	±0".057	±0".353
120737	60°	41	5".30	±0".047	±0".299
120737	120°	38	5".32	±0".046	±0".286
120737	Left	59	5".31	±0".035	±0".269
120737	Right	58	5".28	±0".044	±0".332
120740	00°	43	5".40	±0".046	±0".304
120740	60°	39	5".34	±0".061	±0".378
120740	120°	36	5".36	±0".057	±0".342
120740	Left	61	5".37	±0".043	±0".335
120740	Right	57	5".37	±0".046	±0".347
120741	00°	37	5".39	±0".050	±0".306
120741	60°	33	5".33	±0".053	±0".303
120741	120°	32	5".42	±0".050	±0".281
120741	Left	52	5".38	±0".048	±0".349
120741	Right	50	5".38	±0".033	±0".235

* Sea level correction not applied.

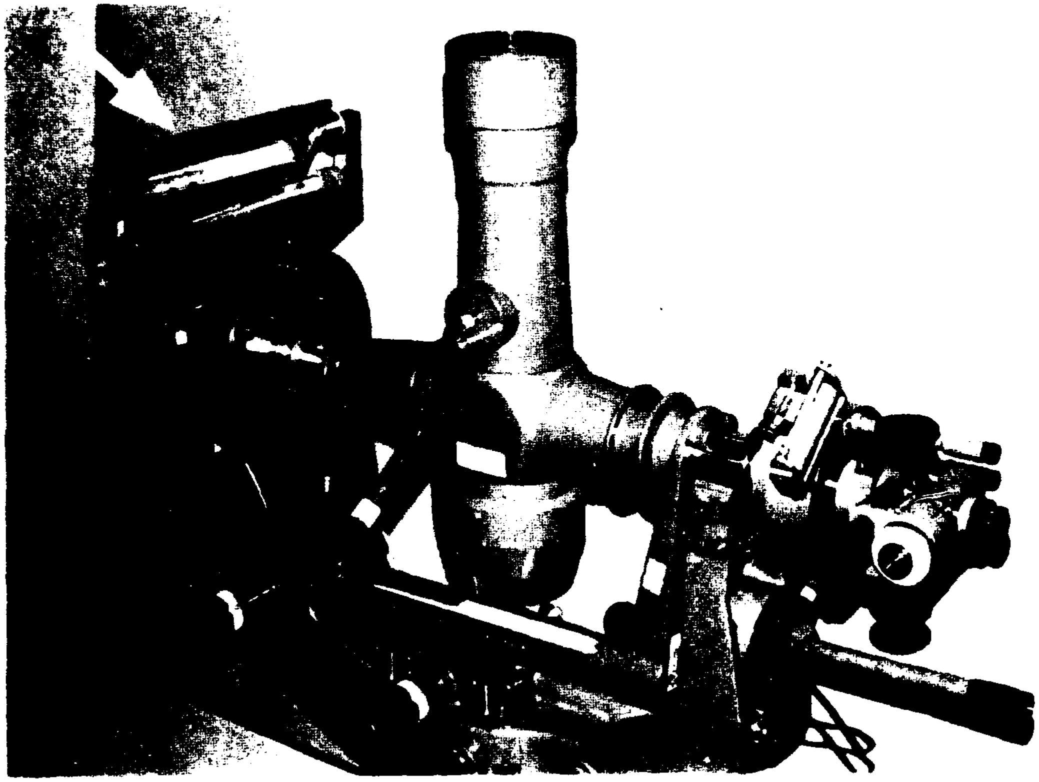

Figure 1. Modified vertical circle level on Wild T-4 theodolite.

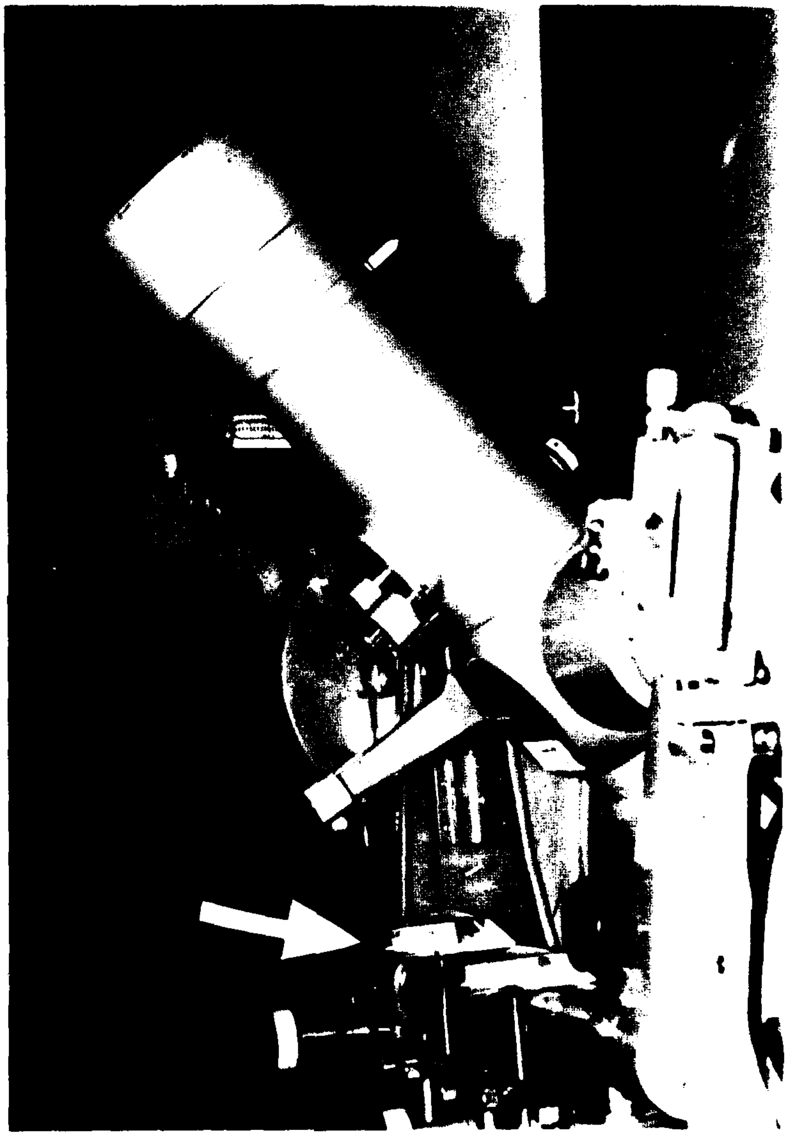

Figure 2. Prism attachments on Wild T-4 theodolite.

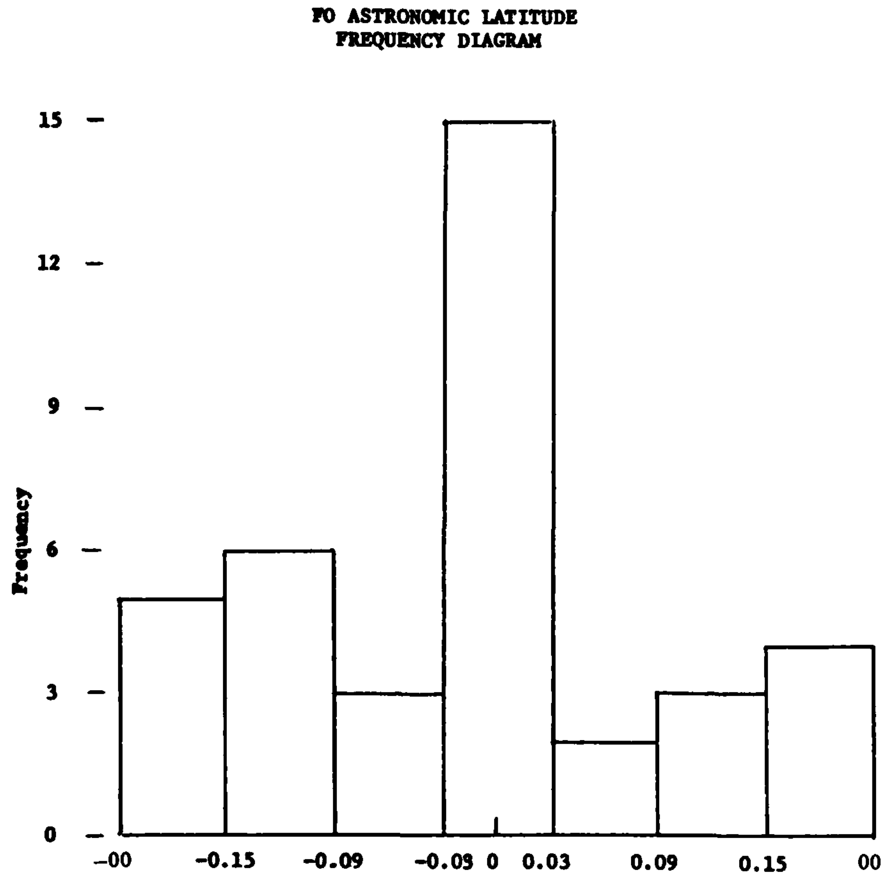

Figure 3. FO latitude displacement from standard in arc seconds.

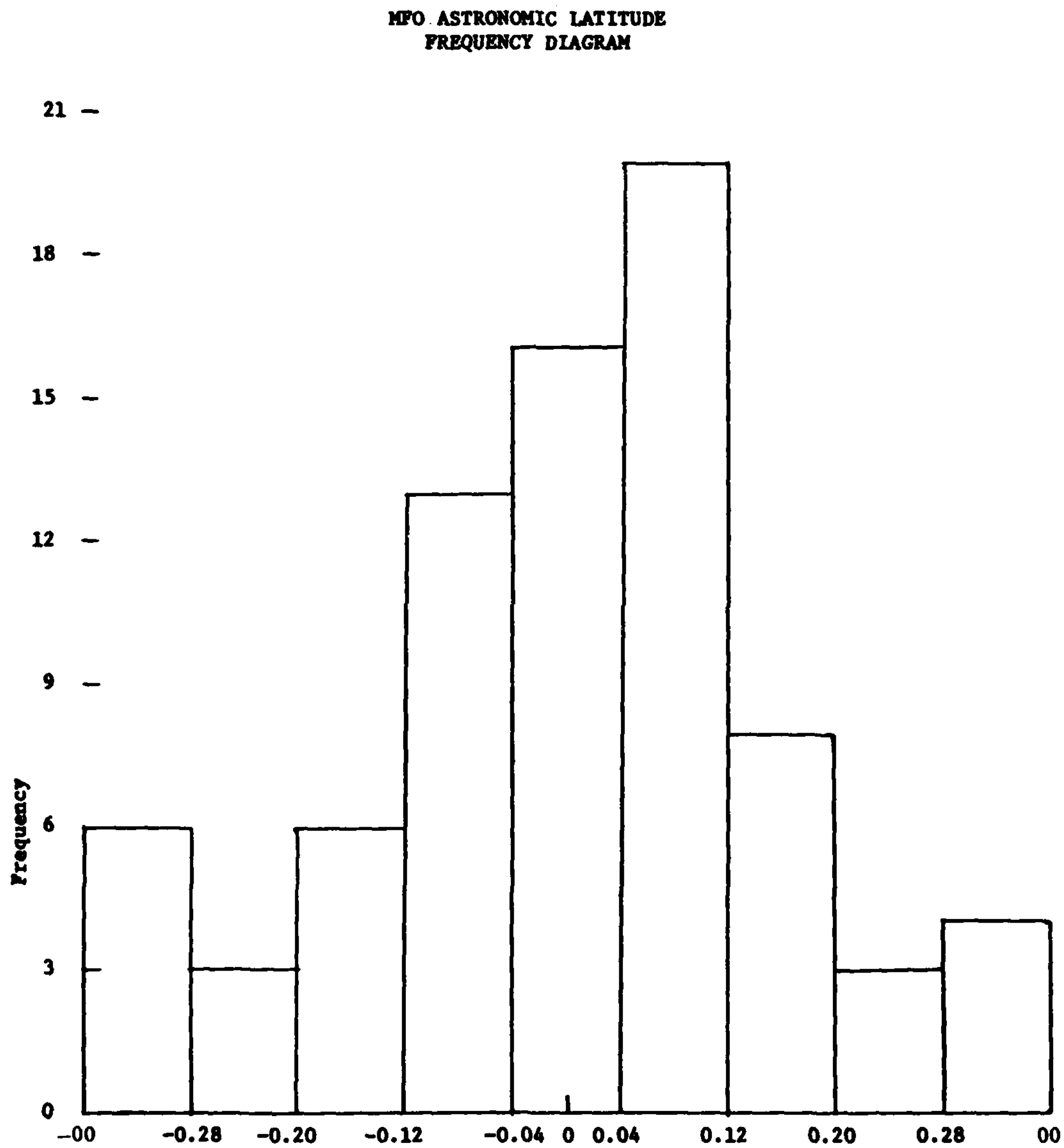

Figure 4. MFO latitude displacement from standard in arc seconds.

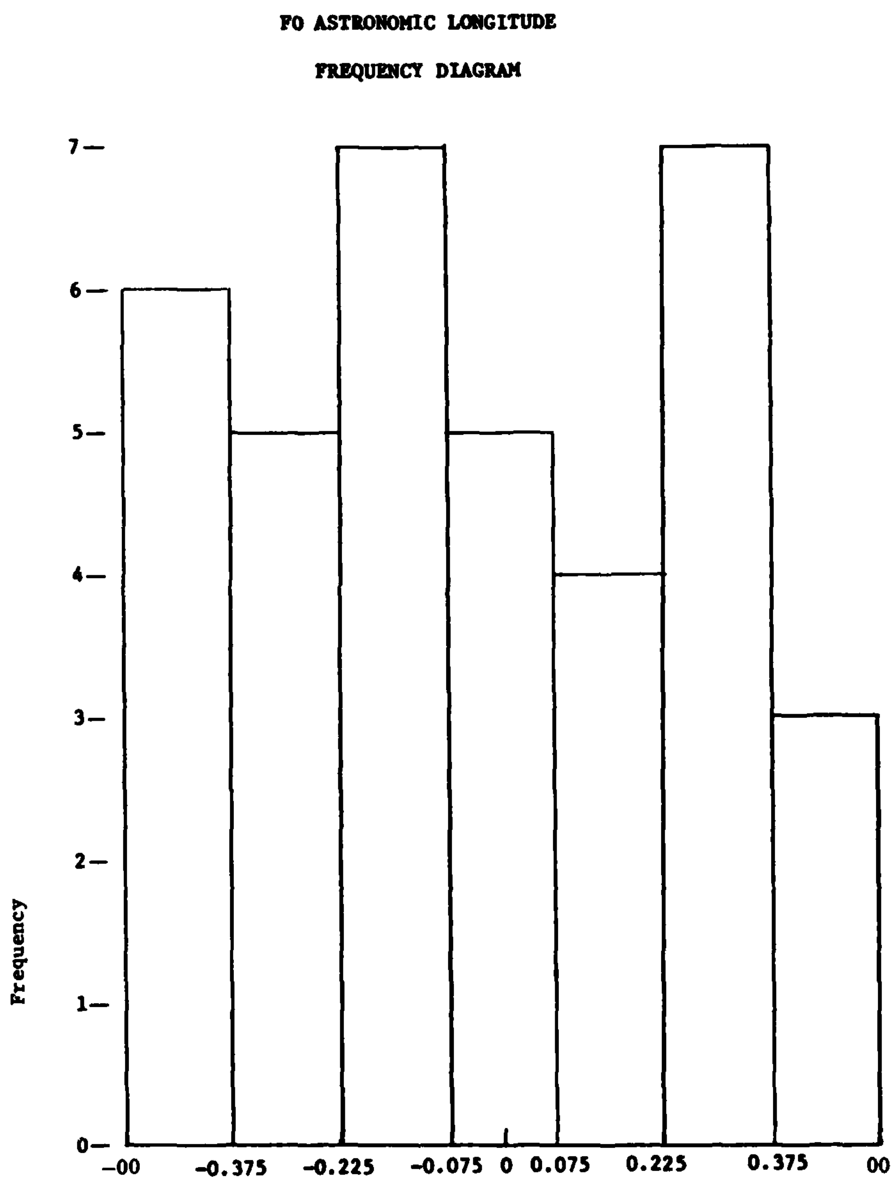

Figure 5. FO longitude displacement from standard in arc seconds.

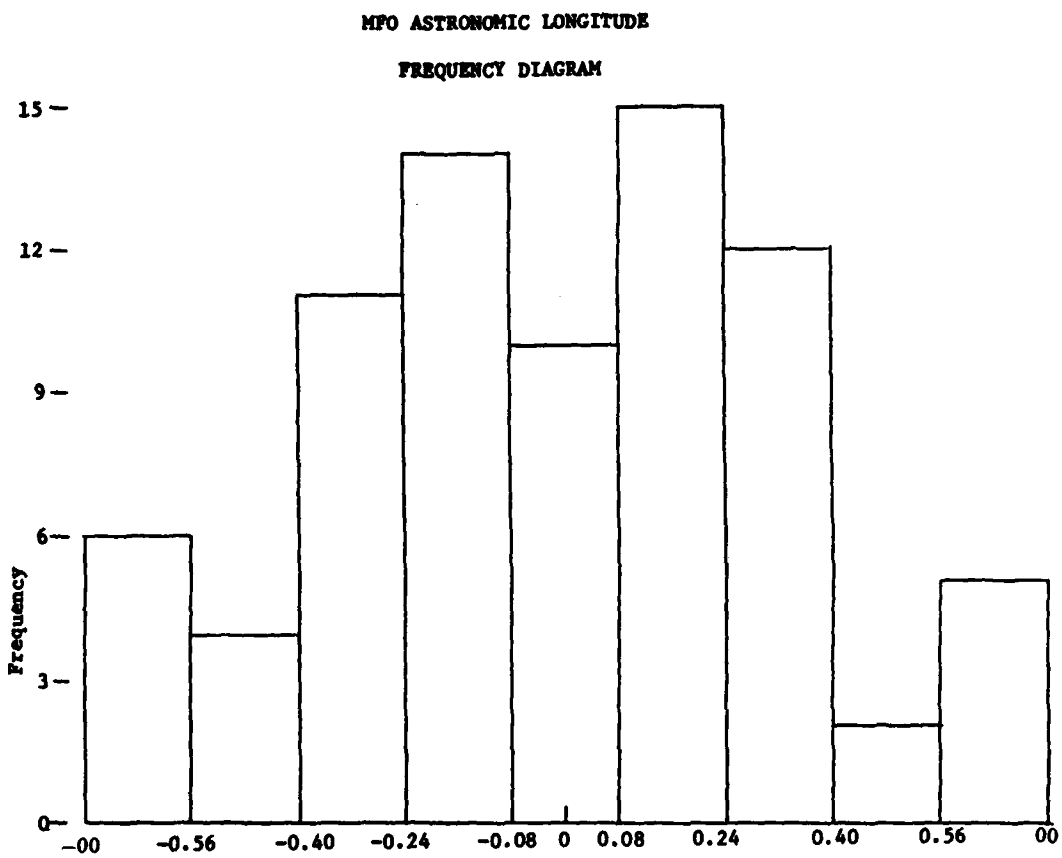

Figure 6. MFO longitude displacement from standard in arc seconds.

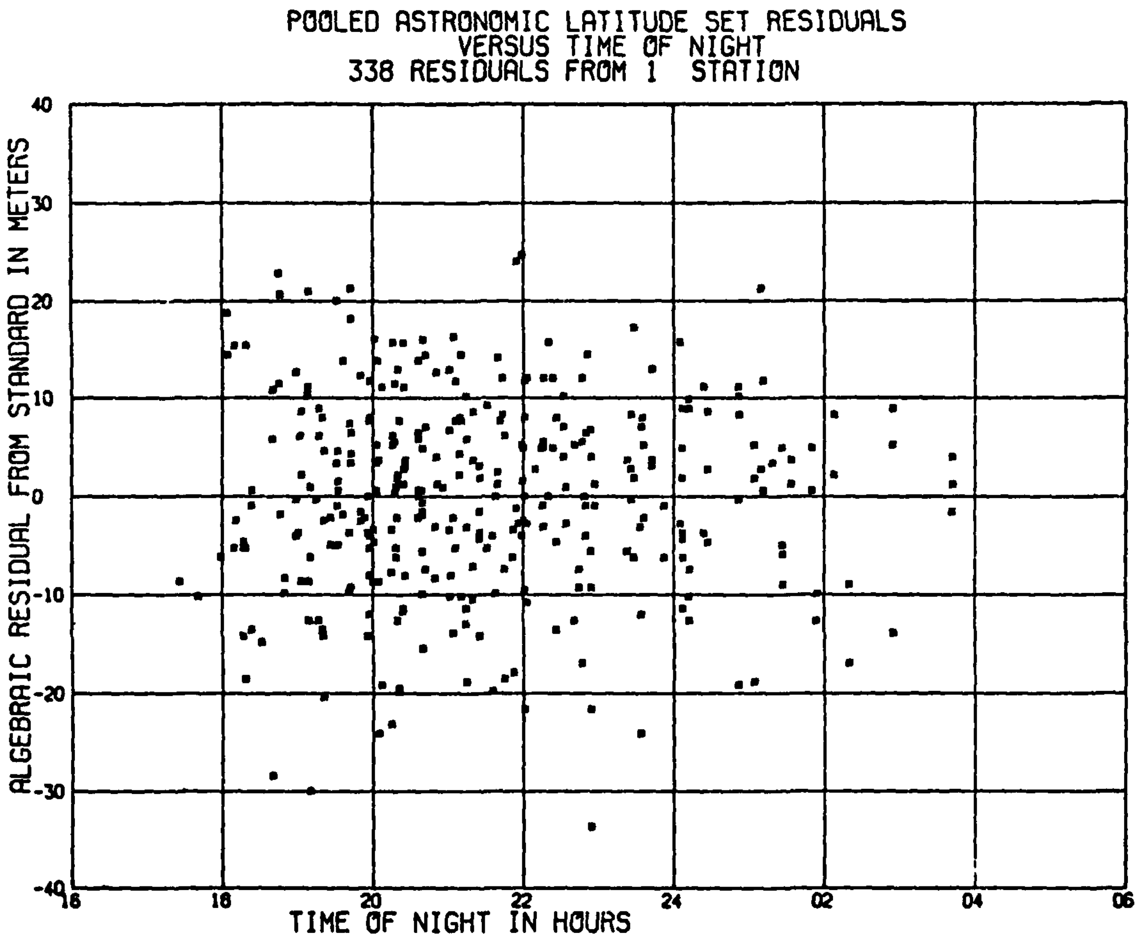

Figure 7. Pooled astronomic latitude set residuals versus time of night.

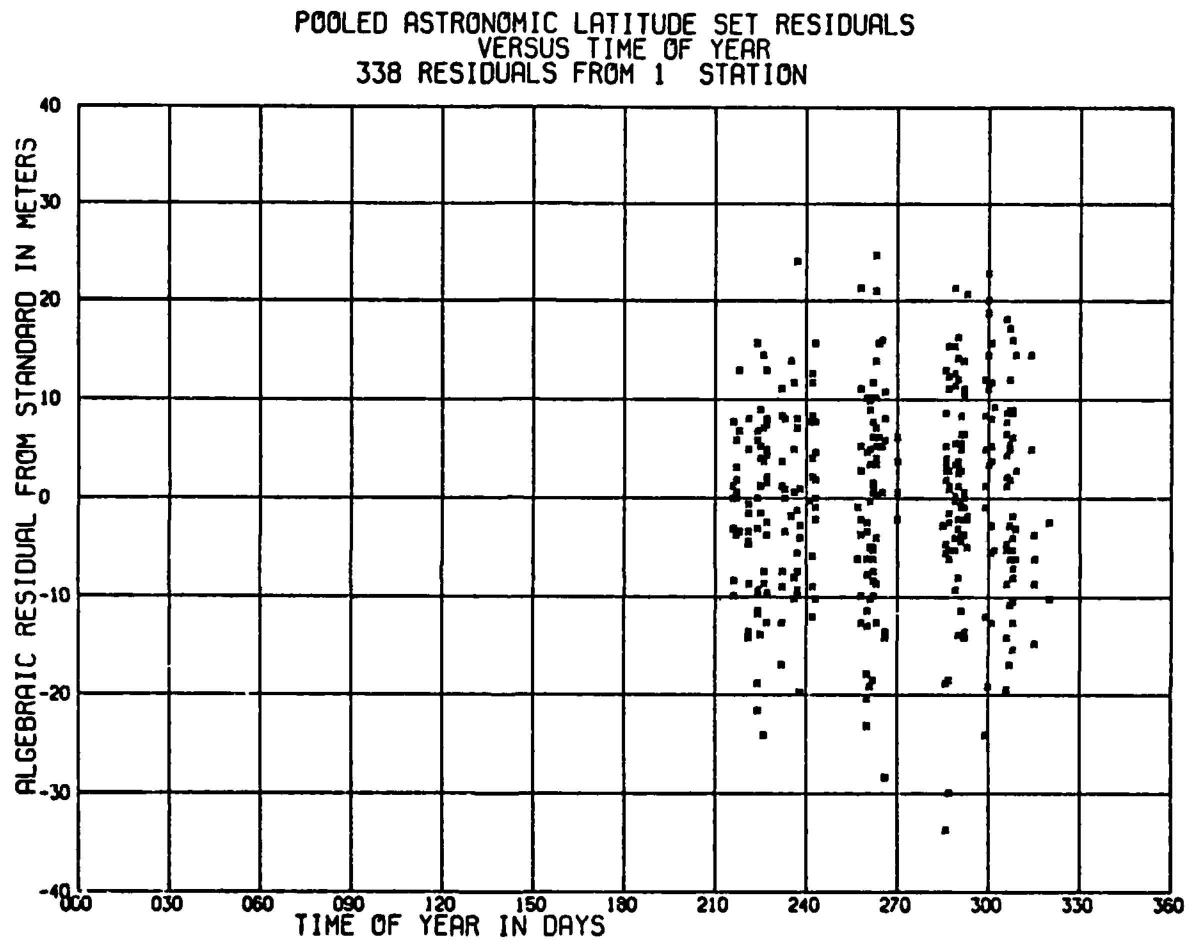

Figure 8. Pooled astronomic latitude set residuals versus time of year.

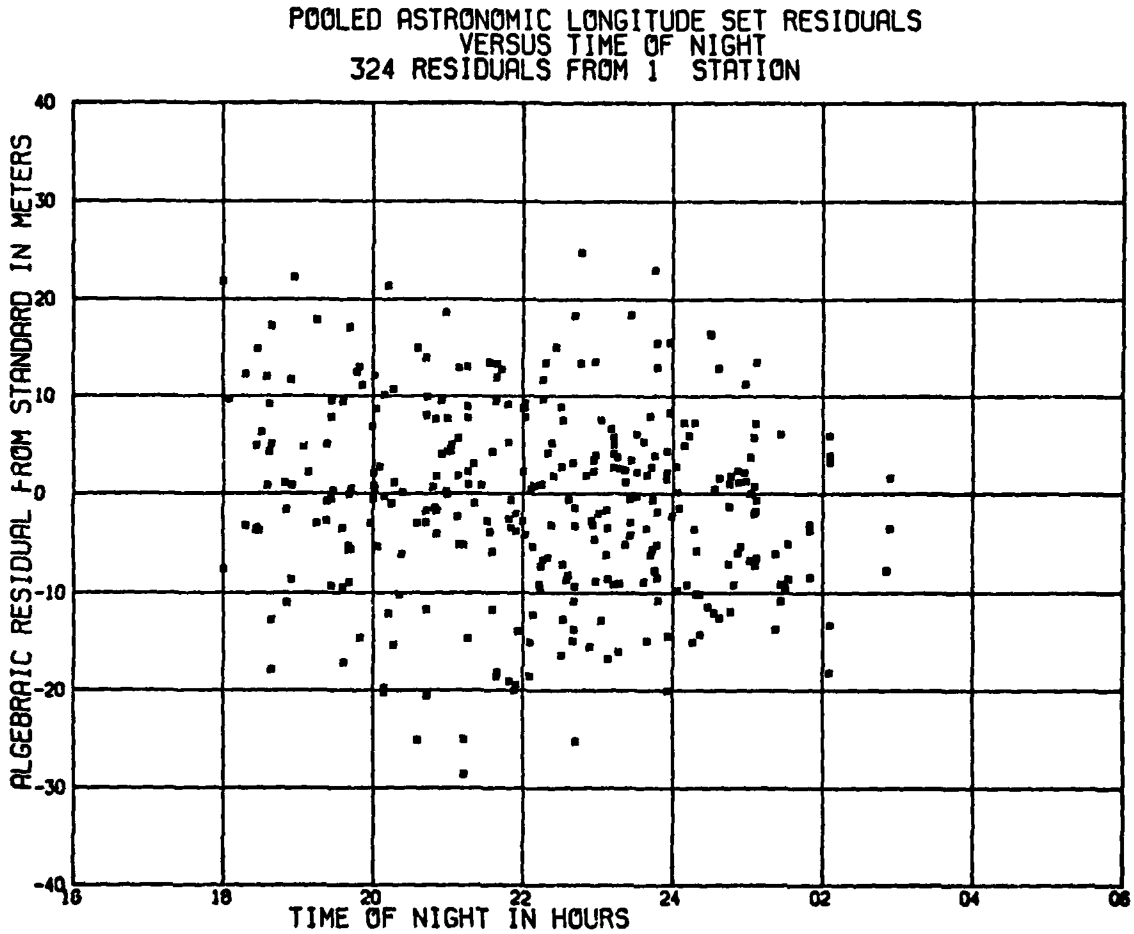

Figure 9. Pooled astronomic longitude set residuals versus time of night.

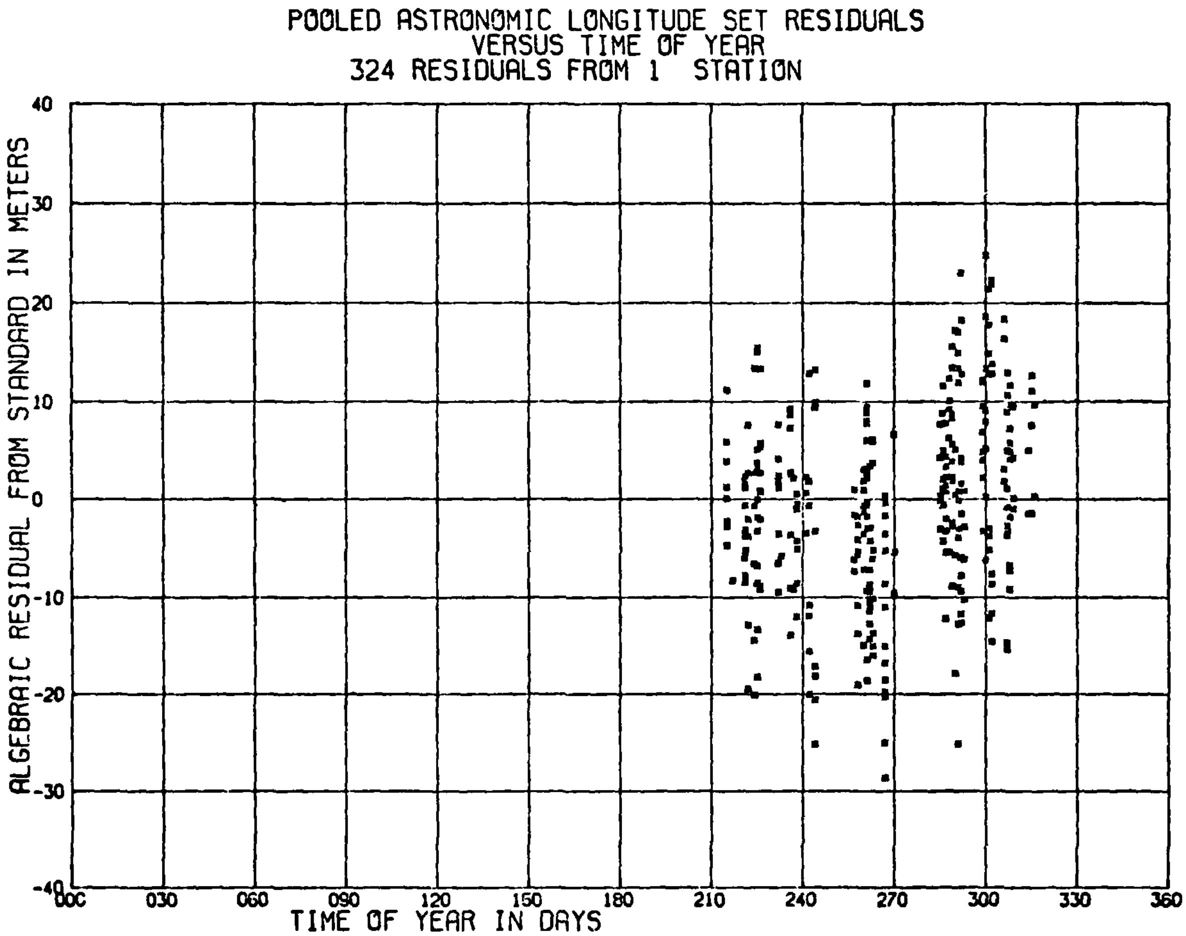

Figure 10. Pooled astronomic longitude set residuals versus time of year.

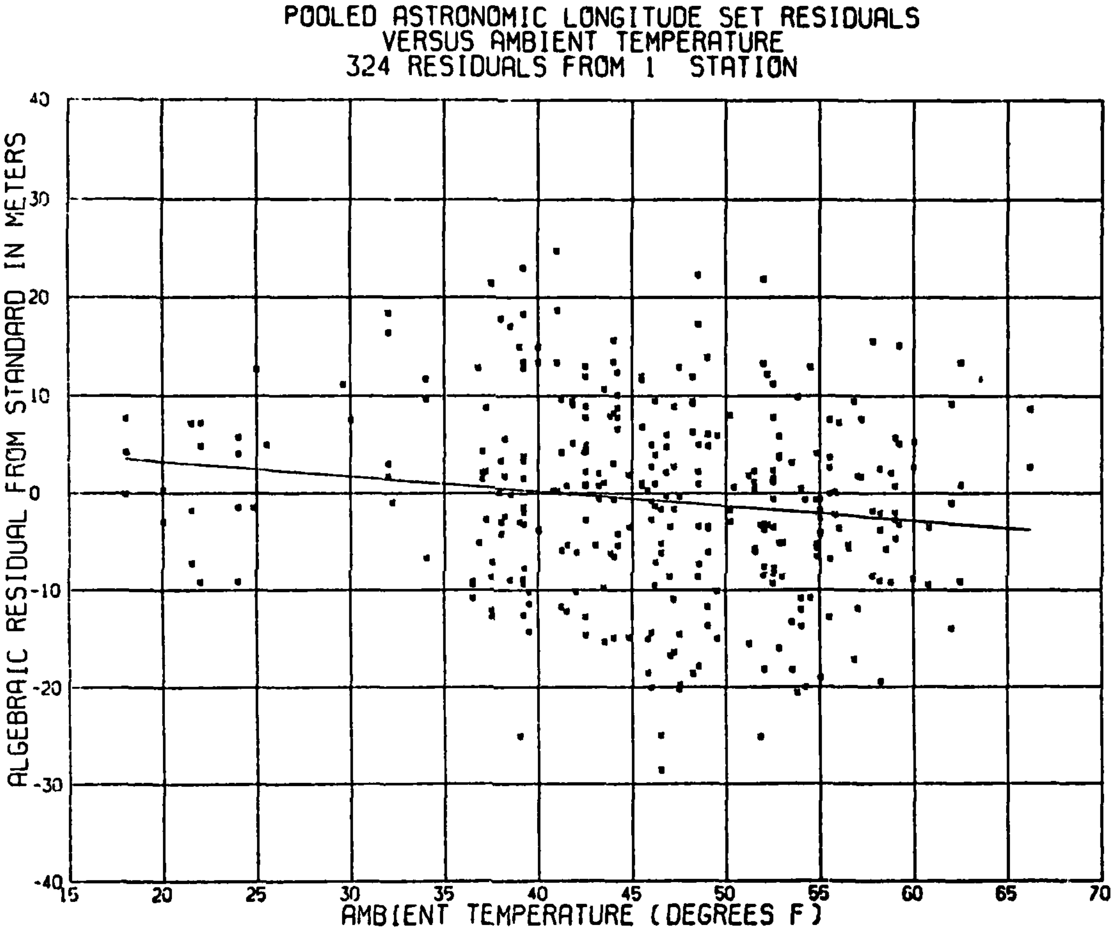

Figure 11. Pooled astronomic longitude set residuals versus ambient temperature.

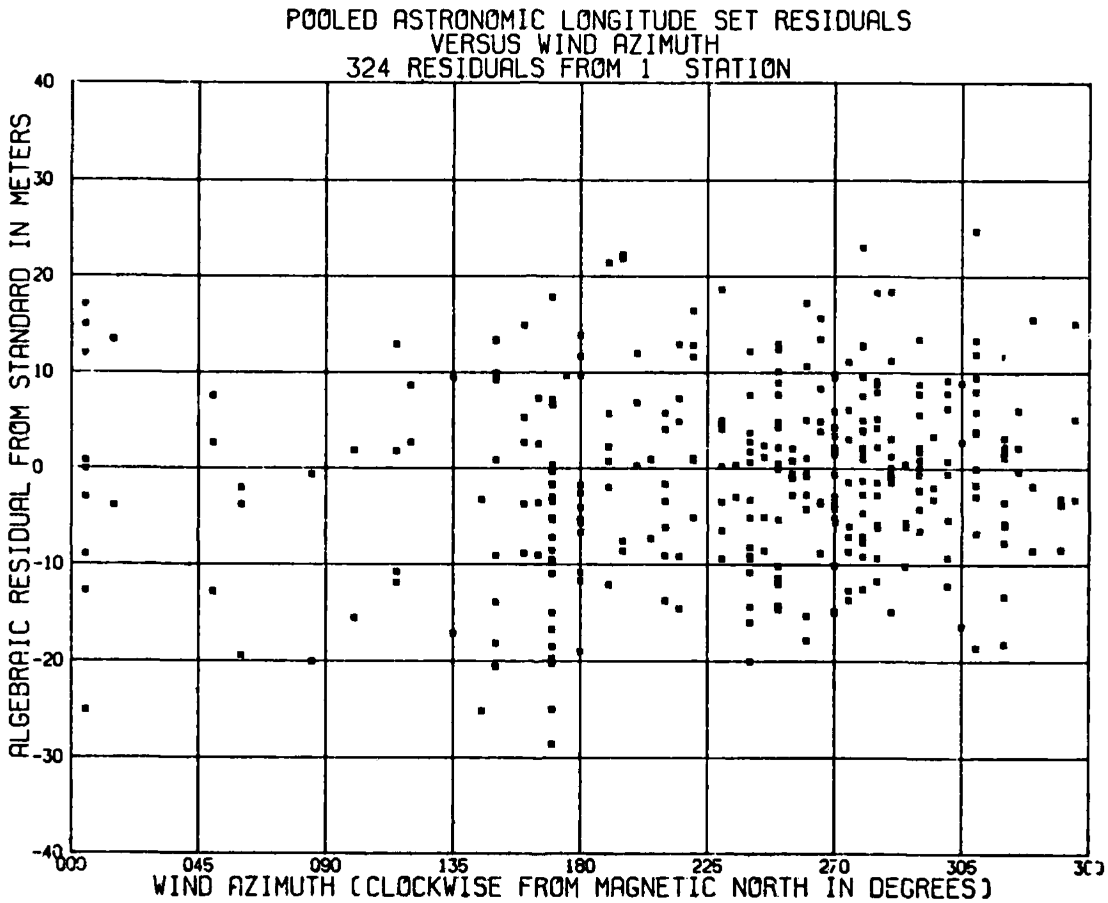

Figure 12. Pooled astronomic longitude set residuals versus wind azimuth.

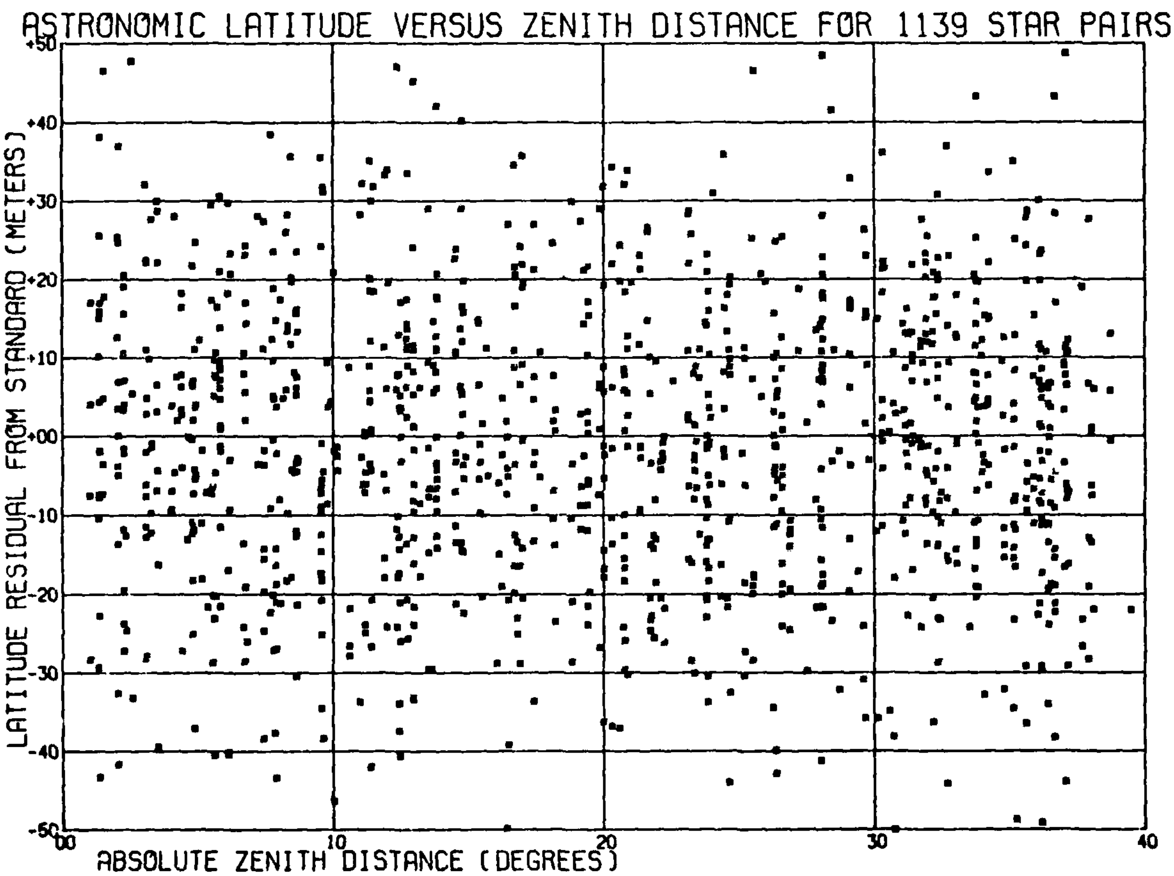

Figure 13. Astronomic latitude versus zenith distance for 1139 star pairs.

APPENDIX A

ASTRONOMIC LATITUDE SET DATA

Explanation of Appendix A

Data for each observed set of astronomic latitude are shown grouped by observer. Each observer's results are sorted in chronological order. The latitude value in arc seconds does not contain a sea-level correction. The YRGCD code of 77216 means Greenwich Civil day 216, year 1977 or 4 August 1977. All local mean times are Mountain Standard times. The set sigma is a precision standard error of the latitude for a set in arc seconds. The sign convention of the zenith distance sum is +north, -south. Wind azimuths reflect the direction from which the wind is blowing. Values of the wind azimuth are measured clockwise from magnetic north.

Items listed for each observed set are:

Column	Description
1	Set number.
2	Latitude value, arc seconds only.
3	Number of acceptable stars.
4	Year (2 digits) and Greenwich Civil day (3 digits).
5	Local Mean Civil time, hours.
6	Time span, minutes.
7	Precision standard error of set, arc seconds.
8	Instrument.
9	Observer.
10	Zenith distance sum (+north; -south), degrees.
11	Zenith distance average, degrees.
12	Absolute zenith point correction, arc seconds.
13	Wind speed, knots.
14	Wind azimuth, degrees.
15	Atmospheric pressure, inches of Mercury.
16	Dry bulb temperature, degrees Fahrenheit.
17	Wet bulb temperature, degrees Fahrenheit.

THEODORE ASTRONOMIC LATITUDE AT F.E. WARREN AFB, WYOMING 41 DEGREES 08 MINUTES

SET	LATITUDE SECONDS	STARS ACC	VRGCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	ZENITH DIST. SUM DEG	ZENITH DIST. AVERAGE DEG	ABSOLUTE ZENITH PT. CORRECTION SECONDS	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
1	5.24	8	77216	20.8	29	0.20	T4120741	AUSTIN	1.60	19.20	22.78	6	355	24.88	53.8	*
2	5.02	10	77216	21.6	59	0.16	T4120741	AUSTIN	-7.70	28.70	21.28	6	335	24.88	53.2	*
3	5.33	8	77217	20.6	35	0.27	T4120741	AUSTIN	4.30	18.70	3.93	8	175	24.05	56.2	54.0
4	5.22	8	77217	21.4	49	0.22	T4120741	AUSTIN	3.50	25.00	4.88	6	190	24.00	55.5	53.8
5	5.23	7	77218	21.0	45	0.25	T4120741	AUSTIN	13.10	28.10	0.34	8	0	24.08	55.5	55.0
6	5.06	8	77221	20.0	38	0.18	T4120741	AUSTIN	3.80	10.90	2.30	15	0	23.91	64.5	57.5
7	5.50	7	77221	20.7	33	0.12	T4120741	AUSTIN	-5.20	27.70	2.83	13	0	23.92	63.5	56.5
8	4.88	8	77221	21.4	45	0.31	T4120741	AUSTIN	-2.30	27.70	3.34	13	0	23.92	63.0	56.8
9	4.90	8	77221	22.4	65	0.13	T4120741	AUSTIN	-0.10	26.40	4.84	10	0	23.93	60.5	55.5
10	4.97	8	77224	20.4	40	0.31	T4120740	AUSTIN	3.30	20.80	2.44	1	205	24.12	48.5	47.5
11	5.24	8	77224	21.3	35	0.21	T4120740	AUSTIN	-1.40	28.50	1.38	4	175	24.12	49.0	48.0
12	4.64	8	77224	22.0	38	0.32	T4120740	AUSTIN	1.90	19.60	0.44	3	170	24.14	49.5	48.5
13	4.64	8	77224	22.9	42	0.39	T4120740	AUSTIN	1.70	24.20	0.32	3	170	24.14	47.5	46.8
14	5.63	9	77225	26.9	48	0.22	T4120740	AUSTIN	-21.70	21.50	1.11	11	360	24.00	52.0	45.5
15	5.47	8	77225	27.7	41	0.15	T4120740	AUSTIN	-3.40	21.20	1.07	12	10	24.00	49.2	45.8
16	5.06	8	77226	20.1	30	0.24	T4120740	AUSTIN	-5.90	21.90	5.04	8	185	23.90	64.8	55.2
17	5.81	8	77226	20.7	37	0.27	T4120740	AUSTIN	-0.10	21.40	5.46	10	175	23.90	64.0	55.0
18	5.58	8	77227	19.7	32	0.32	T4120737	AUSTIN	-4.00	12.60	1.16	6	225	23.93	61.5	58.8
19	5.76	8	77227	20.3	40	0.30	T4120737	AUSTIN	1.60	24.20	0.98	5	205	23.94	61.2	58.8
20	5.48	8	77227	21.2	44	0.37	T4120737	AUSTIN	1.90	27.40	1.16	5	190	23.94	60.8	58.5
21	5.26	7	77227	22.0	43	0.25	T4120737	AUSTIN	9.90	23.60	0.85	9	180	23.95	59.2	57.8
22	5.07	8	77216	20.8	29	0.21	T4120740	WHITE	1.60	19.20	27.08	6	355	24.88	53.8	*
23	5.34	10	77216	21.6	59	0.18	T4120740	WHITE	-7.60	28.70	25.72	6	335	24.88	53.2	*
24	5.36	7	77217	20.6	35	0.19	T4120740	WHITE	-26.80	17.00	3.39	8	175	24.05	56.2	54.0
25	5.44	8	77217	21.4	49	0.22	T4120740	WHITE	3.50	25.00	3.05	6	190	24.00	55.5	53.8
26	5.76	6	77218	21.0	44	0.46	T4120740	WHITE	51.50	26.30	0.30	8	0	24.08	55.5	55.0
27	5.23	8	77221	20.0	38	0.34	T4120740	WHITE	3.80	10.90	1.32	15	0	23.91	64.5	57.5
28	5.29	8	77221	20.7	33	0.15	T4120740	WHITE	5.20	25.60	0.42	13	0	23.92	63.5	56.5
29	5.29	8	77221	21.4	45	0.13	T4120740	WHITE	-2.30	27.70	1.28	13	0	23.92	63.0	56.8
30	5.60	8	77221	22.4	65	0.31	T4120740	WHITE	-0.10	26.40	0.36	10	0	23.93	60.5	55.5
31	4.96	8	77224	20.4	40	0.24	T4120737	WHITE	3.30	20.80	1.05	1	205	24.12	48.5	47.5
32	4.73	8	77224	21.3	35	0.22	T4120737	WHITE	-1.40	28.50	1.88	4	175	24.12	49.0	48.0
33	5.34	8	77224	22.0	38	0.18	T4120737	WHITE	1.90	19.60	2.16	3	170	24.14	49.5	48.5
34	5.04	8	77224	22.9	42	0.20	T4120737	WHITE	1.70	24.20	2.39	3	170	24.14	47.5	46.8
35	5.51	9	77225	26.9	48	0.16	T4120737	WHITE	-21.70	21.50	2.56	11	360	24.00	52.0	45.5
36	5.29	8	77225	27.7	41	0.24	T4120737	WHITE	-3.40	21.20	3.33	12	10	24.00	49.2	45.8
37	4.56	8	77226	20.1	30	0.38	T4120737	WHITE	63.50	21.00	1.67	8	185	23.90	64.8	55.2
38	5.57	8	77226	20.7	37	0.21	T4120737	WHITE	-0.10	21.40	2.04	10	175	23.90	64.0	55.0
39	5.22	8	77227	19.7	32	0.19	T4120741	WHITE	-4.00	12.60	0.82	6	225	23.93	61.5	58.8
40	5.41	8	77227	20.3	40	0.17	T4120741	WHITE	1.60	24.20	0.88	5	205	23.94	61.2	58.8
41	5.41	8	77227	21.2	44	0.27	T4120741	WHITE	1.90	27.40	1.25	5	190	23.94	60.8	58.5
42	5.39	8	77227	22.0	43	0.21	T4120741	WHITE	3.80	21.40	0.36	9	180	23.95	59.2	57.8
43	5.38	7	77216	20.9	26	0.15	T4120737	SALVERMOSER	-5.60	20.90	19.50	6	355	24.88	53.8	*
44	5.59	9	77216	21.7	52	0.15	T4120737	SALVERMOSER	16.80	29.20	22.94	6	335	24.88	53.2	*
45	5.34	8	77217	20.6	35	0.19	T4120737	SALVERMOSER	4.30	18.70	1.94	8	175	24.05	56.2	54.0
46	5.40	8	77217	21.4	48	0.21	T4120737	SALVERMOSER	3.50	25.00	1.66	6	190	24.00	55.5	53.8
47	5.56	8	77218	21.0	45	0.41	T4120737	SALVERMOSER	105.70	26.50	13.88	8	0	24.08	55.5	55.0
48	5.19	8	77221	20.0	38	0.27	T4120737	SALVERMOSER	3.80	10.90	16.70	15	0	23.91	64.5	57.8
49	5.32	8	77221	20.7	33	0.25	T4120737	SALVERMOSER	5.00	25.60	16.86	13	0	23.92	63.5	56.5
50	5.20	8	77221	21.4	45	0.15	T4120737	SALVERMOSER	-2.30	27.70	16.76	13	0	23.92	63.0	56.8
51	5.19	8	77221	22.4	65	0.29	T4120737	SALVERMOSER	-0.10	26.40	17.50	10	0	23.93	60.5	55.5
52	5.85	8	77224	20.4	40	0.36	T4120741	SALVERMOSER	3.30	20.80	0.74	1	205	24.12	48.5	47.5
53	5.53	8	77224	21.3	35	0.38	T4120741	SALVERMOSER	-1.40	28.50	0.75	4	175	24.12	49.0	48.0
54	5.05	8	77224	22.0	38	0.24	T4120741	SALVERMOSER	1.90	19.60	6.69	3	170	24.14	49.5	48.5
55	5.56	8	77224	22.9	42	0.32	T4120741	SALVERMOSER	1.70	24.20	6.36	3	170	24.14	47.5	46.8
56	4.89	8	77225	26.9	48	0.15	T4120741	SALVERMOSER	-11.30	22.90	27.12	11	360	24.00	52.0	45.5
57	5.30	8	77225	27.7	41	0.21	T4120741	SALVERMOSER	-3.40	21.20	27.28	12	10	24.00	49.2	45.8
58	5.46	8	77226	20.1	30	0.23	T4120741	SALVERMOSER	-5.90	21.90	18.58	8	185	23.90	64.8	55.2
59	5.10	8	77226	20.7	37	0.28	T4120741	SALVERMOSER	-0.10	21.40	18.13	10	175	23.90	64.0	55.0
60	5.03	8	77227	19.7	32	0.13	T4120740	SALVERMOSER	-4.00	12.60	3.94	6	225	23.93	61.5	58.8
61	4.93	8	77227	20.3	40	0.17	T4120740	SALVERMOSER	1.60	24.20	4.26	5	205	23.94	61.2	58.8
62	5.60	8	77227	21.2	44	0.37	T4120740	SALVERMOSER	1.90	27.20	785.21	5	190	23.94	60.8	58.5
63	5.50	8	77227	22.0	44	0.24	T4120740	SALVERMOSER	3.80	21.40	785.22	9	180	23.95	59.2	57.8
64	4.93	8	77232	24.2	42	0.26	T4120740	CADDESS	-1.10	17.20	14.57	7	270	24.10	52.5	50.8
65	5.61	8	77232	24.9	32	0.12	T4120740	CADDESS	3.50	16.30	15.40	7	270	24.10	54.8	51.2

* NOT ENOUGH ACCEPTABLE STARS
R REJECTED IN FIRST ORDER COMPUTATION

THEODORE ASTRONOMIC LATITUDE AT F.E. WARREN AFB, WYOMING 41 DEGREES 08 MINUTES

SET	LATITUDE SECONDS	STARS ACC	YRGCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	ZENITH DIST. SUM DEG	ZENITH DIST. AVERAGE DEG	ABSOLUTE ZENITH PT. CORRECTION SECONDS	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
66	5.46	8	77232	25.6	33	0.31	T4120740	CADDESS	-3.30	20.00	18.46	8	290	24.10	53.2	50.8
67	4.79	8	77232	26.3	42	0.29	T4120740	CADDESS	0.20	13.80	18.10	8	285	24.10	51.5	49.0
68	5.28	7	77235	19.6	23	0.19	T4120740	CADDESS	13.20	24.80	31.95	4	125	23.88	61.2	50.2
69	5.01	8	77236	21.0	34	0.25	T4120740	CADDESS	-0.40	19.90	69.29	13	325	23.92	64.5	55.8
70	5.72	8	77236	25.2	38	0.13	T4120740	CADDESS	0.90	16.30	69.20	4	340	23.98	53.5	51.2
71	5.50	8	77236	25.8	32	0.17	T4120740	CADDESS	0.70	20.60	69.26	2	215	23.98	52.2	50.8
72	5.16	8	77237	20.7	79	0.27	T4120737	CADDESS	2.10	29.80	35.14	9	285	23.82	62.2	54.0
73	6.12	6	77237	21.9	46	0.24	T4120737	CADDESS	28.80	27.70	33.71	7	240	23.82	61.0	52.5
74	5.04	8	77237	22.7	41	0.09	T4120737	CADDESS	2.90	9.30	35.51	8	255	23.82	61.5	52.5
75	5.60	8	77237	23.6	40	0.41	T4120737	CADDESS	-2.40	18.90	33.24	11	265	23.84	61.5	53.0
76	5.21	7	77238	21.6	56	0.26	T4120737	CADDESS	6.10	15.20	34.62	6	255	23.80	62.0	53.2
77	5.25	8	77238	22.6	40	0.21	T4120737	CADDESS	1.60	14.00	34.36	5	200	23.80	59.0	52.2
78	4.95	7	77242	20.0	49	0.22	T4120737	CADDESS	-32.10	28.60	40.73	6	100	24.00	61.5	51.5
79	5.75	8	77242	20.8	38	0.19	T4120737	CADDESS	1.90	19.60	40.94	6	100	24.02	59.0	51.0
80	5.15	8	77242	25.5	32	0.22	T4120737	CADDESS	0.70	20.60	34.11	7	115	23.99	53.5	46.2
81	5.41	8	77242	26.1	30	0.28	T4120737	CADDESS	-0.10	16.10	34.40	5	120	23.99	50.0	45.8
82	5.31	8	77243	19.5	43	0.26	T4120740	CADDESS	-4.60	22.00	116.12	5	115	23.82	63.0	50.8
83	5.27	8	77243	20.3	41	0.37	T4120740	CADDESS	3.70	25.40	117.08	6	190	23.82	61.0	49.0
84	5.59	8	77243	21.2	50	0.22	T4120740	CADDESS	-2.10	23.00	119.24	4	180	23.84	58.0	48.0
85	5.34	8	77243	22.3	39	0.18	T4120740	CADDESS	-5.00	15.70	119.07	5	170	23.87	57.0	48.0
86	5.10	8	77232	24.2	42	0.30	T4120737	ZEIGLER	-1.10	17.30	32.78	7	270	24.10	52.5	50.8
87	5.70	7	77232	24.9	32	0.39	T4120737	ZEIGLER	-28.90	14.00	31.88	7	270	24.10	54.8	51.2
88	5.38	8	77232	25.6	33	0.42	T4120737	ZEIGLER	-3.30	20.00	34.26	8	290	24.10	53.2	50.8
89	5.05	8	77232	26.3	42	0.20	T4120737	ZEIGLER	0.20	13.80	33.26	8	285	24.10	51.5	49.0
90	5.60	8	77233	20.0	52	0.22	T4120737	ZEIGLER	22.00	15.70	29.86	6	360	23.99	62.8	53.2
91	5.37	8	77233	20.9	46	0.24	T4120737	ZEIGLER	15.90	19.70	30.10	11	10	24.00	61.5	51.2
92	5.23	8	77233	21.9	50	0.10	T4120737	ZEIGLER	4.90	13.50	28.06	9	360	24.01	59.5	50.2
93	5.34	8	77233	22.8	50	0.23	T4120737	ZEIGLER	-8.60	17.40	27.56	9	350	24.02	57.8	49.2
94	5.79	7	77235	19.6	23	0.15	T4120737	ZEIGLER	39.40	24.20	35.20	4	125	23.88	61.2	50.5
95	5.08	8	77236	21.0	34	0.19	T4120737	ZEIGLER	-0.40	19.90	35.42	13	325	23.92	64.5	55.8
96	5.36	8	77236	25.2	38	0.39	T4120737	ZEIGLER	0.90	16.30	36.14	4	340	23.98	53.5	51.2
97	5.36	8	77236	25.8	32	0.18	T4120737	ZEIGLER	0.70	20.60	35.96	2	215	23.98	52.2	50.8
98	5.02	8	77237	20.7	79	0.18	T4120740	ZEIGLER	2.10	29.80	71.90	9	285	23.82	62.2	54.0
99	5.30	8	77237	21.9	46	0.11	T4120740	ZEIGLER	-2.60	24.70	71.45	7	240	23.82	61.0	52.5
100	5.10	8	77237	22.7	41	0.23	T4120740	ZEIGLER	2.90	9.30	71.74	8	255	23.82	61.5	52.5
101	5.57	7	77237	23.6	39	0.08	T4120740	ZEIGLER	15.20	19.10	27.26	11	265	23.84	61.5	53.0
102	4.70	8	77238	21.6	56	0.30	T4120740	ZEIGLER	-0.10	14.10	29.50	6	255	23.80	62.0	53.2
103	5.37	8	77238	22.6	40	0.31	T4120740	ZEIGLER	1.50	14.00	29.04	5	200	23.80	59.0	52.2
104	5.33	8	77241	19.3	29	0.22	T4120740	ZEIGLER	-26.40	25.20	114.80	10	220	24.14	52.5	48.2
105	5.59	8	77241	20.0	39	0.18	T4120740	ZEIGLER	31.10	25.00	114.50	10	200	24.16	51.4	47.2
106	5.72	8	77242	20.0	49	0.22	T4120741	ZEIGLER	-0.50	29.00	0.32	6	100	24.00	61.5	51.5
107	5.47	8	77242	20.8	38	0.19	T4120741	ZEIGLER	1.90	19.60	0.61	6	100	24.02	59.0	51.0
108	5.05	8	77242	25.5	32	0.16	T4120741	ZEIGLER	0.70	20.60	4.04	7	115	23.99	53.5	46.2
109	5.61	8	77242	26.1	30	0.10	T4120741	ZEIGLER	-0.10	16.10	4.20	5	120	23.99	50.0	45.8
110	5.49	8	77243	19.5	43	0.31	T4120741	ZEIGLER	-4.60	22.00	13.16	5	115	23.82	63.0	50.8
111	5.40	8	77243	20.3	41	0.30	T4120741	ZEIGLER	-3.70	25.40	13.08	6	190	23.82	61.0	49.0
112	5.01	8	77243	21.2	50	0.18	T4120741	ZEIGLER	-2.10	23.00	13.74	4	180	23.84	58.0	48.0
113	5.85	8	77243	22.3	38	0.18	T4120741	ZEIGLER	-4.90	15.00	13.18	5	170	23.87	57.0	48.0
114	5.31	8	77257	23.9	26	0.30	T4120737	PERELKA	-3.20	20.00	1.26	4	170	24.02	45.2	42.0
115	5.22	8	77258	23.6	37	0.08	T4120737	PERELKA	-1.80	22.30	1.24	4	240	23.88	51.8	45.0
116	5.43	8	77258	24.4	32	0.52	T4120737	PERELKA	-1.30	21.20	1.27	8	220	23.87	50.8	42.8
117	5.63	8	77258	25.2	40	0.25	T4120737	PERELKA	0.60	20.40	1.40	6	180	23.86	48.0	41.5
118	3.02	8	77258	25.9	42	0.19	T4120737	PERELKA	-4.00	27.70	1.20	5	240	23.85	48.5	41.5
119	5.26	8	77260	19.3	38	0.26	T4120737	PERELKA	-5.00	19.50	18.27	7	200	23.82	55.5	45.0
120	4.95	8	77260	20.3	60	0.34	T4120737	PERELKA	-4.70	19.20	18.21	6	225	23.85	52.0	43.0
121	4.92	8	77260	21.2	36	0.11	T4120737	PERELKA	-3.40	6.90	20.15	5	285	23.84	47.2	39.5
122	4.76	7	77260	21.9	31	0.43	T4120737	PERELKA	-27.20	16.00	20.84	4	300	23.84	44.8	38.0
123	5.01	8	77261	24.2	32	0.28	T4120740	PERELKA	-2.50	21.00	2.85	12	340	23.98	46.5	36.8
124	5.33	8	77261	24.9	32	0.22	T4120740	PERELKA	-3.20	22.20	3.08	19	320	24.00	45.5	37.0
125	5.18	8	77261	25.4	28	0.30	T4120740	PERELKA	-3.30	27.40	2.71	17	315	24.01	44.0	36.0
126	5.02	8	77262	18.8	34	0.23	T4120740	PERELKA	-3.50	28.70	2.98	5	100	24.04	51.0	40.8
127	5.18	8	77262	19.5	36	0.28	T4120740	PERELKA	-4.60	20.40	5.81	5	80	24.06	47.8	38.2
128	5.17	8	77262	20.3	42	0.18	T4120740	PERELKA	-0.50	24.50	6.10	5	70	24.07	45.3	37.0
129	5.72	8	77262	21.1	36	0.22	T4120740	PERELKA	-3.40	6.90	22.98	4	90	24.09	42.5	35.5
130	5.10	8	77262	21.8	36	0.13	T4120740	PERELKA	-1.10	19.80	22.34	3	270	24.10	41.0	34.5

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THEODORE ASTRONOMIC LATITUDE AT F.E. WARREN AFB, WYOMING 41 DEGREES 08 MINUTES

SET	LATITUDE SECONDS	STARS ACC	YRGCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	ZENITH DIST. SUM DEG	ZENITH DIST. AVERAGE DEG	ABSOLUTE ZENITH PT. CORRECTION SECONDS	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
131	6.02	7	77263	19.2	38	0.31	T4120741	PERELKA	-29.70	26.10	4.84	5	255	23.88	54.8	44.0
132	5.79	8	77263	20.1	60	0.24	T4120741	PERELKA	2.60	18.30	5.06	4	270	23.89	53.8	43.2
133	6.14	8	77263	22.0	27	0.24	T4120741	PERELKA	-2.10	23.30	0.76	10	230	23.88	59.5	45.0
134	5.47	8	77263	22.5	30	0.26	T4120741	PERELKA	4.40	12.70	0.39	8	215	23.88	55.8	44.0
135	5.85	8	77264	20.3	59	0.27	T4120741	PERELKA	-41.10	21.80	69.80	14	15	23.82	60.8	47.8
136	5.51	7	77265	20.0	75	0.29	T4120741	PERELKA	16.40	18.10	12.18	1	35	24.00	51.2	39.8
137	5.69	8	77256	18.7	33	0.26	T4120741	PERELKA	-2.50	23.00	25.46	4	170	23.73	60.0	45.2
138	5.60	8	77266	19.3	43	0.21	T4120741	PERELKA	-4.80	22.50	25.93	5	170	23.73	59.0	44.8
139	5.14	8	77257	23.9	26	0.31	T4120741	PHILLIPS	-3.20	20.00	43.31	4	230	24.02	45.2	42.0
140	5.27	8	77258	23.6	47	0.31	T4120741	PHILLIPS	1.80	12.30	43.28	8	240	23.88	51.8	43.0
141	5.70	8	77258	24.4	32	0.24	T4120741	PHILLIPS	-4.30	21.20	43.95	6	220	23.87	50.8	42.8
142	6.03	8	77258	25.2	40	0.27	T4120741	PHILLIPS	0.60	20.30	59.98	5	180	23.86	48.0	41.5
143	4.93	9	77258	25.9	42	0.29	T4120741	PHILLIPS	37.20	32.40	60.61	8	240	23.85	48.5	41.5
144	4.68	7	77260	19.3	37	0.16	T4120741	PHILLIPS	-6.80	20.60	63.06	7	200	23.82	55.5	45.0
145	5.23	8	77260	20.3	60	0.36	T4120741	PHILLIPS	-4.70	19.20	64.26	6	225	23.83	52.0	43.0
146	4.97	8	77260	21.2	36	0.39	T4120741	PHILLIPS	3.40	6.90	32.41	5	285	23.84	47.2	39.5
147	5.14	8	77260	21.9	31	0.11	T4120741	PHILLIPS	2.10	17.70	33.10	4	300	23.84	44.8	38.0
148	5.66	7	77261	24.2	32	0.44	T4120737	PHILLIPS	-35.70	19.30	33.50	12	340	23.98	46.5	36.8
149	4.72	6	77261	24.9	32	0.25	T4120737	PHILLIPS	39.50	23.80	32.72	19	320	24.00	45.5	37.0
150	5.50	8	77261	25.4	28	0.21	T4120737	PHILLIPS	-3.30	27.40	32.82	17	315	24.01	44.0	36.0
151	5.07	8	77262	18.8	34	0.26	T4120737	PHILLIPS	-3.50	28.90	29.56	5	100	24.02	51.0	40.2
152	5.39	8	77262	19.5	36	0.25	T4120737	PHILLIPS	-4.60	20.40	12.84	5	80	24.04	47.8	38.2
153	5.14	8	77262	20.3	42	0.30	T4120737	PHILLIPS	-0.50	24.50	11.74	5	70	24.07	45.2	37.0
154	5.17	8	77262	21.1	36	0.39	T4120737	PHILLIPS	3.40	6.90	9.92	4	90	24.09	42.5	35.5
155	4.74	8	77262	21.8	36	0.49	T4120737	PHILLIPS	-1.10	19.80	9.94	3	270	24.10	41.0	34.5
156	5.06	8	77263	19.2	38	0.33	T4120740	PHILLIPS	1.50	26.60	29.85	5	255	23.88	54.8	44.0
157	5.45	7	77263	20.0	60	0.32	T4120740	PHILLIPS	-34.00	15.70	30.64	4	270	23.89	53.8	43.2
158	5.51	8	77263	22.0	27	0.14	T4120740	PHILLIPS	-2.00	23.30	12.16	10	230	23.88	59.5	45.0
159	5.57	8	77263	22.5	30	0.26	T4120740	PHILLIPS	4.40	12.70	12.60	8	215	23.88	55.8	44.0
160	5.51	7	77264	20.3	58	0.41	T4120740	PHILLIPS	-6.30	20.00	30.44	14	15	23.82	60.8	47.8
161	5.86	8	77265	20.0	79	0.42	T4120740	PHILLIPS	21.70	16.50	35.10	1	35	24.00	51.2	39.8
162	4.42	7	77266	18.7	33	0.22	T4120740	PHILLIPS	24.80	22.50	0.09	4	170	23.73	60.0	45.2
163	4.90	9	77266	19.3	43	0.24	T4120740	PHILLIPS	-35.30	23.30	0.10	5	170	23.73	59.0	44.8
164	5.14	8	77257	23.9	26	0.20	T4120740	ROBERTS	-3.20	20.00	18.15	4	230	24.02	45.2	42.0
165	5.49	8	77260	19.3	38	0.12	T4120740	ROBERTS	5.00	19.50	28.40	7	200	23.82	55.5	45.0
166	5.09	8	77260	20.3	60	0.18	T4120740	ROBERTS	-4.70	19.20	28.99	6	225	23.83	52.0	43.0
167	5.67	8	77260	21.2	36	0.21	T4120740	ROBERTS	3.40	6.90	29.43	5	285	23.84	47.2	39.5
168	5.23	8	77260	21.9	31	0.38	T4120740	ROBERTS	2.10	17.70	30.33	4	300	23.84	44.8	38.0
169	5.63	8	77261	24.2	32	0.19	T4120741	ROBERTS	-2.50	20.50	0.49	12	340	23.98	46.5	36.8
170	5.67	8	77261	24.9	32	0.20	T4120741	ROBERTS	4.30	22.70	0.50	19	320	24.00	45.5	37.0
171	5.45	8	77261	25.3	29	0.18	T4120741	ROBERTS	-3.30	26.90	0.32	17	315	24.01	44.0	36.0
172	5.07	8	77262	18.8	34	0.22	T4120741	ROBERTS	-3.50	29.20	0.54	5	100	24.02	51.0	40.8
173	5.36	8	77262	19.5	36	0.10	T4120741	ROBERTS	-4.60	20.30	0.08	5	80	24.04	47.8	38.2
174	5.37	8	77262	20.3	42	0.25	T4120741	ROBERTS	-0.50	24.50	0.08	5	70	24.07	45.2	37.0
175	5.59	8	77262	21.1	36	0.26	T4120741	ROBERTS	3.40	6.90	50.52	4	90	24.09	42.5	35.5
176	5.54	8	77262	21.8	36	0.24	T4120741	ROBERTS	-1.10	19.80	51.16	3	270	24.10	41.0	34.5
177	4.93	8	77263	19.2	38	0.29	T4120737	ROBERTS	1.50	26.60	41.70	5	255	23.88	54.8	44.0
178	5.35	7	77263	20.0	60	0.44	T4120737	ROBERTS	-19.10	17.80	42.34	4	270	23.89	53.8	43.2
179	5.21	8	77263	22.0	27	0.15	T4120737	ROBERTS	-2.00	23.30	41.22	10	230	23.88	59.5	45.0
180	5.67	8	77263	22.5	30	0.28	T4120737	ROBERTS	4.40	12.70	41.48	8	215	23.88	55.8	44.0
181	5.54	8	77264	20.3	58	0.16	T4120737	ROBERTS	-41.10	21.80	16.19	14	15	23.82	60.8	47.8
182	5.36	8	77265	20.0	76	0.20	T4120737	ROBERTS	-2.10	18.60	7.04	1	35	24.00	51.2	39.8
183	5.53	8	77266	18.7	33	0.16	T4120737	ROBERTS	-2.50	23.00	79.14	4	170	23.73	60.0	45.2
184	4.80	7	77266	19.3	43	0.16	T4120737	ROBERTS	-43.20	20.20	79.14	5	170	23.73	59.0	44.8
185	5.54	9	77270	19.0	42	0.24	T4120740	ROBERTS	-2.40	24.20	12.84	3	170	23.92	49.2	41.8
186	5.27	7	77270	19.9	42	0.15	T4120740	ROBERTS	31.30	26.10	11.74	2	170	23.92	45.5	39.5
187	5.36	8	77270	20.7	36	0.20	T4120740	ROBERTS	-4.10	17.10	10.13	4	170	23.92	43.8	38.2
188	5.46	7	77270	21.3	33	0.16	T4120740	ROBERTS	16.60	21.40	9.77	3	170	23.94	45.5	39.0
189	5.25	7	77285	21.9	36	0.18	T4120740	BARTON	-0.10	7.40	25.78	1	150	24.21	18.0	*
190	5.16	8	77286	22.9	49	0.48	T4120740	BARTON	-1.40	17.00	40.92	12	290	24.10	40.8	30.0
191	5.44	8	77286	23.7	41	0.25	T4120740	BARTON	-3.40	21.20	41.98	14	290	24.10	34.0	28.0
192	5.62	8	77286	24.5	35	0.32	T4120740	BARTON	1.60	17.40	40.02	12	285	24.09	32.0	*
193	5.51	8	77286	25.1	35	0.33	T4120740	BARTON	-1.00	15.20	41.19	8	275	24.09	32.0	*
194	5.84	7	77287	18.3	48	0.26	T4120740	BARTON	30.10	11.80	37.32	10	290	24.00	50.2	37.0
195	4.37	6	77287	19.2	37	0.38	T4120740	BARTON	44.80	14.10	38.80	10	290	24.02	47.0	35.2

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SET	LATITUDE SECONDS		STARS ACC	YRGCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	ZENITH DIST. SUN DEG	ZENITH DIST. AVERAGE DEG	ABSOLUTE ZENITH PT. CORRECTION SECONDS	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
196	5.26		8	77287	19.8	34	0.16	T4120740	BARTON	1.30	16.70	40.00	12	300	24.06	44.9	33.8
197	5.70		8	77287	20.4	27	0.17	T4120740	BARTON	-2.00	23.30	40.30	12	300	24.08	43.0	33.0
198	-9.99	*	5	77289	18.1	47	0.88	T4120741	BARTON	-31.60	23.20	11.22	7	205	24.15	47.5	40.0
199	5.21		7	77289	19.0	43	0.25	T4120741	BARTON	-5.80	21.40	27.05	6	215	24.15	44.0	38.0
200	5.45		8	77289	19.7	34	0.21	T4120741	BARTON	-1.60	9.00	28.32	5	225	24.16	39.8	35.0
201	5.52		8	77289	20.3	26	0.29	T4120741	BARTON	2.70	23.00	27.16	4	245	24.16	38.5	33.5
202	5.08		8	77290	20.4	39	0.25	T4120741	BARTON	4.00	19.80	38.84	2	270	24.00	51.5	37.2
203	4.89		8	77290	21.1	33	0.30	T4120741	BARTON	1.90	22.60	38.70	1	300	24.01	49.0	36.0
204	5.38		8	77290	21.7	32	0.25	T4120741	BARTON	0.10	15.60	38.45	2	270	24.01	50.0	36.5
205	5.52		8	77290	22.3	36	0.21	T4120741	BARTON	-4.70	21.30	38.22	2	270	24.01	52.5	38.0
206	5.31		7	77291	22.3	35	0.11	T4120737	BARTON	-12.00	12.10	1.90	6	15	24.07	36.5	30.5
207	5.21		8	77291	22.8	25	0.14	T4120737	BARTON	-0.50	22.80	1.25	4	30	24.07	35.0	29.0
208	5.43		8	77291	23.4	35	0.18	T4120737	BARTON	-0.60	18.90	1.75	4	30	24.05	33.5	28.0
209	4.97		8	77291	24.1	35	0.32	T4120737	BARTON	-0.10	14.00	1.43	10	20	24.01	33.8	28.5
210	5.36		7	77292	18.4	36	0.34	T4120737	BARTON	-21.80	24.80	1.07	6	105	23.99	52.0	38.0
211	5.70		8	77292	19.1	41	0.24	T4120737	BARTON	-3.80	11.20	1.16	5	90	23.99	51.5	37.5
212	5.22		8	77292	19.9	36	0.27	T4120737	BARTON	-1.00	23.00	1.47	5	60	23.99	50.2	36.8
213	5.55		8	77292	20.6	34	0.18	T4120737	BARTON	-2.90	25.80	1.04	4	80	24.00	46.2	34.8
214	8.25	*	5	77285	21.9	36	0.59	T4120737	FINCH	4.00	6.00	57.65	1	150	24.22	18.0	.
215	4.25		7	77286	22.9	49	0.41	T4120737	FINCH	14.70	17.20	27.26	12	290	24.10	40.8	30.0
216	5.46		8	77286	23.7	41	0.48	T4120737	FINCH	-3.40	21.20	28.56	14	290	24.10	34.0	28.0
217	5.19		7	77286	24.5	35	0.23	T4120737	FINCH	-29.60	15.50	26.19	12	285	24.09	32.0	.
218	4.73		8	77286	25.1	35	0.24	T4120737	FINCH	-1.00	15.20	27.98	8	275	24.09	32.0	.
219	4.74		8	77287	18.3	48	0.21	T4120737	FINCH	-3.70	14.50	22.04	10	290	24.00	50.2	37.0
220	5.37		7	77287	19.2	37	0.30	T4120737	FINCH	33.90	13.70	22.00	10	290	24.02	47.4	35.2
221	5.74		8	77287	19.8	34	0.31	T4120737	FINCH	1.30	16.80	21.04	12	300	24.06	44.9	33.8
222	5.43		8	77287	20.4	27	0.24	T4120737	FINCH	-2.00	23.30	21.45	12	300	24.08	43.0	33.0
223	5.84		8	77289	18.2	50	0.30	T4120740	FINCH	3.70	20.60	81.30	7	205	24.15	47.5	40.0
224	5.75		8	77289	19.0	43	0.28	T4120740	FINCH	0.50	19.50	82.50	6	215	24.15	44.0	38.0
225	6.03		9	77289	19.7	34	0.28	T4120740	FINCH	3.70	8.60	81.54	5	225	24.16	39.8	35.0
226	5.71		8	77289	20.3	26	0.25	T4120740	FINCH	2.70	23.00	82.50	4	245	24.16	38.5	33.5
227	5.44		8	77290	20.4	39	0.18	T4120740	FINCH	3.50	19.80	74.73	2	270	24.00	51.5	37.2
228	5.87		8	77290	21.1	33	0.22	T4120740	FINCH	1.90	22.60	73.88	1	300	24.01	49.0	36.0
229	5.42		8	77290	21.7	32	0.22	T4120740	FINCH	0.20	15.60	75.70	2	270	24.01	50.0	36.5
230	5.73		8	77290	22.3	37	0.22	T4120740	FINCH	-4.70	21.30	74.58	2	270	24.01	52.5	38.0
231	5.52		8	77291	22.3	35	0.18	T4120741	FINCH	4.30	12.60	35.34	6	15	24.07	36.5	30.5
232	5.55		8	77291	22.8	25	0.19	T4120741	FINCH	-0.50	22.80	35.40	4	30	24.07	35.0	29.1
233	5.61		8	77291	23.4	35	0.09	T4120741	FINCH	-0.60	18.90	34.54	4	30	24.04	33.5	28.1
234	5.20		8	77291	24.1	35	0.06	T4120741	FINCH	-0.10	14.00	34.98	10	20	24.01	33.8	28.5
235	4.90		8	77292	18.4	36	0.22	T4120741	FINCH	0.10	24.30	0.09	6	105	23.99	52.0	38.0
236	5.69		8	77292	19.1	41	0.16	T4120741	FINCH	-3.80	11.30	0.08	5	90	23.99	51.5	37.5
237	4.38		8	77292	19.9	36	0.30	T4120741	FINCH	-1.00	22.90	0.08	5	60	23.99	50.2	36.8
238	5.27		8	77292	20.6	34	0.26	T4120741	FINCH	-2.90	25.90	0.10	4	80	24.00	46.2	34.8
239	7.29	*	5	77285	21.9	36	0.27	T4120741	ZELLERS	-9.90	3.20	89.32	1	150	24.22	18.0	.
240	5.47		8	77286	22.9	49	0.30	T4120741	ZELLERS	-1.40	17.00	37.99	12	290	24.10	40.8	30.0
241	5.76		8	77286	23.7	41	0.15	T4120741	ZELLERS	-3.40	21.20	38.14	14	290	24.10	34.0	28.0
242	5.43		8	77286	24.5	35	0.37	T4120741	ZELLERS	-1.60	17.40	36.24	12	285	24.09	32.0	.
243	5.40		8	77286	25.1	34	0.21	T4120741	ZELLERS	-1.00	15.20	34.88	8	275	24.09	32.0	.
244	5.17		8	77287	18.3	48	0.22	T4120741	ZELLERS	-3.70	14.50	27.51	10	290	24.00	50.2	37.0
245	5.14		9	77287	19.2	37	0.23	T4120741	ZELLERS	-2.00	16.40	27.92	10	290	24.02	47.4	35.2
246	5.29		8	77287	19.8	34	0.26	T4120741	ZELLERS	-1.30	16.80	26.94	12	300	24.06	44.9	33.8
247	5.38		8	77287	20.4	27	0.12	T4120741	ZELLERS	-2.00	23.30	27.37	12	300	24.08	43.0	33.0
248	5.17		8	77289	18.2	50	0.20	T4120737	ZELLERS	3.70	20.60	130.02	7	205	24.15	47.5	40.0
249	5.33		8	77289	19.0	43	0.25	T4120737	ZELLERS	0.50	19.50	5.19	6	215	24.15	44.0	38.0
250	5.04		8	77289	19.7	34	0.27	T4120737	ZELLERS	-1.60	9.00	6.22	5	225	24.16	39.8	35.0
251	5.35		8	77289	20.3	26	0.24	T4120737	ZELLERS	2.70	23.00	5.37	4	245	24.16	38.5	33.5
252	5.46		8	77290	20.4	39	0.34	T4120737	ZELLERS	3.50	19.80	3.22	2	270	24.00	51.5	37.2
253	5.27		6	77290	21.1	33	0.26	T4120737	ZELLERS	1.90	22.60	1.88	1	300	24.01	49.0	36.0
254	5.80		8	77290	21.7	32	0.21	T4120737	ZELLERS	0.10	15.60	3.20	2	270	24.01	50.0	36.5
255	5.24		8	77290	22.3	36	0.28	T4120737	ZELLERS	-4.70	21.30	2.84	2	270	24.01	52.5	38.0
256	5.50		7	77291	22.3	35	0.33	T4120740	ZELLERS	26.40	21.30	74.68	6	15	24.07	36.5	30.5
257	5.31		8	77291	22.8	25	0.15	T4120740	ZELLERS	-0.50	22.80	74.29	4	30	24.07	35.0	29.0
258	5.33		8	77291	23.4	35	0.40	T4120740	ZELLERS	-0.60	18.90	74.48	4	30	24.05	33.5	28.0
259	5.22		7	77291	24.1	35	0.27	T4120740	ZELLERS	-9.80	14.60	74.21	10	20	24.01	33.8	28.5
260	5.31		8	77292	18.4	36	0.20	T4120740	ZELLERS	0.10	24.40	62.38	6	105	23.99	32.0	38.0

* NOT ENOUGH ACCEPTABLE STARS
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THEODORE ASTRONOMIC LATITUDE AT F.E. WARREN AFB, WYOMING 41 DEGREES 08 MINUTES

SET	LATITUDE SECONDS	STARS ACC	YRGCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	ZENITH DIST. SUM DEG	ZENITH DIST. AVERAGE DEG	ABSOLUTE ZENITH PT. CORRECTION SECONDS	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
261	5.67	8	77292	19.1	41	0.28	T4120740	ZELLERS	-3.80	11.20	61.14	5	90	23.99	51.5	37.5
262	5.34	8	77292	19.9	36	0.26	T4120740	ZELLERS	-1.00	23.00	61.28	5	60	23.99	50.2	36.8
263	5.79	8	77292	20.6	34	0.20	T4120740	ZELLERS	-2.90	25.80	62.56	4	80	24.00	46.2	34.8
264	6.01	8	77293	18.8	37	0.32	T4120740	BERNARD	2.80	16.10	1.36	2	245	23.88	46.8	35.0
265	5.27	8	77293	19.4	33	0.23	T4120740	BERNARD	-0.30	20.20	1.36	1	300	23.88	45.2	33.8
266	5.61	8	77299	21.7	32	0.33	T4120740	BERNARD	0.40	20.60	26.43	5	280	23.89	44.0	34.5
267	5.73	8	77299	22.4	30	0.25	T4120740	BERNARD	-0.10	16.10	25.60	5	270	23.89	44.0	33.8
268	5.31	8	77299	23.0	28	0.40	T4120740	BERNARD	0.70	26.90	27.07	5	260	23.89	45.2	34.2
269	4.95	8	77299	23.6	31	0.24	T4120740	BERNARD	1.00	20.20	26.18	5	265	23.89	43.5	33.8
270	5.81	8	77300	18.1	33	0.27	T4120740	BERNARD	-0.90	24.50	21.91	4	235	23.86	50.0	36.2
271	6.08	8	77300	18.8	43	0.23	T4120740	BERNARD	-0.90	12.70	22.02	4	240	23.86	46.0	34.0
272	5.99	8	77300	19.5	30	0.19	T4120740	BERNARD	-0.20	19.60	22.04	3	295	23.87	43.8	33.0
273	5.70	8	77300	20.1	33	0.22	T4120740	BERNARD	1.40	17.90	21.10	5	245	23.88	42.8	32.8
274	5.60	8	77301	22.0	37	0.28	T4120741	BERNARD	3.40	12.50	0.59	2	270	23.97	35.5	31.8
275	5.51	8	77301	22.7	35	0.23	T4120741	BERNARD	-1.80	21.60	0.66	6	240	23.97	33.8	31.5
276	5.16	8	77301	23.4	38	0.26	T4120741	BERNARD	4.30	21.30	0.67	5	235	23.97	29.8	*
277	5.25	8	77301	24.1	38	0.33	T4120741	BERNARD	-3.80	19.70	0.67	4	225	23.97	26.0	*
278	5.64	8	77302	21.5	32	0.34	T4120741	BERNARD	0.50	20.60	34.86	5	205	23.92	50.0	39.0
279	5.17	8	77306	18.3	34	0.36	T4120741	BERNARD	1.30	14.20	40.10	6	270	23.89	32.5	*
280	5.62	8	77306	19.0	40	0.33	T4120741	BERNARD	0.20	15.90	39.38	7	265	23.90	32.0	*
281	5.55	7	77306	19.7	30	0.17	T4120741	BERNARD	32.50	17.90	39.78	12	285	23.89	32.5	*
282	5.38	8	77306	20.3	42	0.30	T4120741	BERNARD	-2.10	17.80	39.84	16	285	23.88	33.5	*
283	4.99	7	77307	22.0	35	0.32	T4120737	BERNARD	14.30	15.70	30.58	1	200	23.84	39.0	33.5
284	5.73	8	77307	22.8	32	0.22	T4120737	BERNARD	-2.90	21.70	30.17	7	200	23.86	36.8	32.0
285	5.40	8	77307	23.5	35	0.20	T4120737	BERNARD	0.50	15.10	30.88	1	10	23.88	35.2	32.5
286	5.50	9	77307	24.1	27	0.31	T4120737	BERNARD	-20.00	21.10	30.46	1	245	23.90	30.0	*
287	4.93	8	77308	19.3	35	0.34	T4120737	BERNARD	3.50	20.00	18.46	7	170	24.02	35.0	31.2
288	5.17	8	77308	20.0	39	0.23	T4120737	BERNARD	2.40	24.80	18.22	6	170	24.02	34.5	31.2
289	4.84	8	77308	20.7	27	0.24	T4120737	BERNARD	2.70	21.90	17.48	8	155	24.02	34.5	31.5
290	5.00	8	77308	21.3	44	0.16	T4120737	BERNARD	3.10	21.00	17.98	9	145	24.02	34.5	32.0
291	5.28	8	77293	18.8	37	0.21	T4120737	WOODARD	2.80	16.10	1.28	2	245	23.88	46.8	35.0
292	5.18	8	77293	19.4	33	0.30	T4120737	WOODARD	-0.30	20.20	1.38	1	300	23.88	45.2	33.8
293	5.73	7	77299	21.7	32	0.32	T4120737	WOODARD	-17.50	21.00	3.87	5	280	23.89	44.0	34.5
294	5.50	7	77299	22.4	30	0.40	T4120737	WOODARD	24.70	14.90	4.78	5	270	23.89	44.0	33.8
295	5.38	8	77299	23.0	28	0.24	T4120737	WOODARD	0.70	26.90	3.73	5	260	23.89	45.2	34.2
296	4.56	7	77299	23.6	31	0.36	T4120737	WOODARD	33.10	18.50	4.08	5	265	23.89	43.5	33.8
297	5.95	7	77300	18.1	33	0.13	T4120737	WOODARD	25.20	24.20	5.66	4	235	23.86	50.0	36.2
298	5.71	8	77300	18.8	43	0.22	T4120737	WOODARD	-0.90	12.70	5.14	4	240	23.86	46.0	34.0
299	5.45	8	77300	19.5	30	0.15	T4120737	WOODARD	-0.20	19.60	5.29	3	295	23.87	43.8	33.0
300	4.72	8	77300	20.1	33	0.36	T4120737	WOODARD	1.40	17.90	5.03	5	245	23.88	42.8	32.8
301	5.72	8	77301	22.0	37	0.31	T4120740	WOODARD	3.40	13.20	92.38	2	270	23.97	35.5	31.8
302	4.93	8	77301	22.7	35	0.34	T4120740	WOODARD	-1.80	21.00	93.44	6	240	23.97	33.8	31.5
303	5.46	8	77301	23.4	38	0.32	T4120740	WOODARD	4.30	21.90	91.80	5	235	23.97	29.8	*
304	5.85	8	77301	24.1	38	0.37	T4120740	WOODARD	-3.80	19.00	92.74	4	225	23.97	26.0	*
305	5.17	8	77302	21.5	32	0.21	T4120740	WOODARD	0.50	20.60	17.74	5	205	23.92	50.2	39.0
306	4.88	8	77306	18.3	34	0.34	T4120740	WOODARD	1.30	14.20	76.68	6	270	23.89	32.5	*
307	5.41	8	77306	19.0	40	0.23	T4120740	WOODARD	0.20	15.90	77.40	7	265	23.90	32.0	*
308	5.93	7	77306	19.7	30	0.28	T4120740	WOODARD	5.00	19.10	75.80	12	285	23.89	32.5	*
309	4.71	7	77306	20.3	42	0.21	T4120740	WOODARD	24.00	16.50	77.20	16	285	23.88	33.5	*
310	5.73	8	77307	22.0	35	0.43	T4120741	WOODARD	-2.70	15.90	38.42	1	200	23.84	39.0	33.5
311	5.52	8	77307	22.8	32	0.34	T4120741	WOODARD	-2.90	21.70	38.66	7	200	23.86	36.8	32.0
312	5.90	6	77307	23.5	35	0.17	T4120741	WOODARD	-0.60	16.30	38.38	1	10	23.88	35.2	32.5
313	5.40	8	77307	24.1	28	0.37	T4120741	WOODARD	-14.00	22.90	38.88	1	245	23.90	30.0	*
314	5.63	7	77308	19.3	36	0.26	T4120741	WOODARD	19.40	20.60	2.18	7	170	24.02	35.0	31.2
315	5.21	8	77308	20.0	39	0.30	T4120741	WOODARD	2.40	24.80	1.02	6	170	24.02	34.5	31.2
316	5.86	7	77308	20.7	27	0.25	T4120741	WOODARD	31.10	21.00	1.41	8	155	24.02	34.5	31.5
317	5.11	8	77308	21.3	44	0.39	T4120741	WOODARD	3.10	20.90	1.14	9	145	24.02	34.5	32.0
318	5.19	8	77306	18.3	34	0.23	T4120737	COURBIS	1.30	14.30	31.68	6	270	23.89	32.5	*
319	5.06	8	77306	19.0	40	0.24	T4120737	COURBIS	0.20	15.90	32.22	7	265	23.90	32.0	*
320	5.48	8	77306	19.7	30	0.29	T4120737	COURBIS	3.50	19.30	31.35	12	285	23.89	32.5	*
321	5.59	8	77306	20.3	42	0.25	T4120737	COURBIS	-2.10	17.90	32.04	16	285	23.88	33.5	*
322	5.25	8	77307	22.0	35	0.27	T4120740	COURBIS	-2.70	15.80	72.76	1	200	23.84	39.0	33.5
323	4.79	8	77307	22.8	32	0.20	T4120740	COURBIS	-2.90	21.70	73.50	7	200	23.86	36.8	32.0
324	5.14	8	77307	23.5	35	0.26	T4120740	COURBIS	0.50	15.10	72.46	1	10	23.88	35.2	32.5
325	5.63	8	77307	24.1	27	0.39	T4120740	COURBIS	6.10	20.40	72.00	1	245	23.90	30.0	*

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THEODORE ASTRONOMIC LATITUDE AT F.E. WARREN AFB, WYOMING 41 DEGREES 08 MINUTES

SET	LATITUDE SECONDS	STARS ACC	YRGCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	ZENITH DIST. SUM DEG	ZENITH DIST. AVERAGE DEG	ABSOLUTE ZENITH PT. CORRECTION SECONDS	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
326	5.54	8	77308	19.3	35	0.21	T4120740	COURBIS	3.80	20.10	10.74	7	170	24.02	35.0	31.2
327	5.08	7	77308	20.0	39	0.26	T4120740	COURBIS	-5.70	27.20	9.22	6	170	24.02	34.5	31.2
328	5.29	8	77308	20.7	27	0.27	T4120740	COURBIS	2.70	22.00	11.10	8	155	24.02	34.5	31.5
329	5.62	8	77308	21.3	44	0.15	T4120740	COURBIS	3.10	20.90	9.93	9	145	24.02	34.5	32.0
330	5.43	8	77309	22.2	36	0.29	T4120737	COURBIS	-1.40	23.80	20.54	3	310	23.95	30.4	.
331	5.81	8	77309	22.8	39	0.30	T4120737	COURBIS	4.80	23.50	21.24	1	165	23.93	30.8	.
332	5.24	7	77309	23.5	36	0.40	T4120737	COURBIS	-15.60	13.90	20.54	1	265	23.91	30.9	.
333	5.14	7	77309	24.1	25	0.33	T4120737	COURCIS	-36.40	21.80	22.56	6	255	23.90	30.9	.
334	5.81	8	77314	21.2	85	0.35	T4120741	COURBIS	2.80	19.30	34.16	16	280	23.96	25.5	.
335	5.50	8	77314	22.2	39	0.30	T4120741	COURBIS	4.50	21.90	33.94	14	275	23.96	25.0	.
336	5.06	9	77315	17.4	35	0.26	T4120741	COURBIS	-3.10	15.60	76.80	10	330	24.09	36.8	30.3
337	5.14	8	77315	18.0	27	0.43	T4120741	COURBIS	7.70	19.70	76.84	12	320	24.10	35.8	.
338	4.86	9	77315	18.5	28	0.27	T4120741	COURBIS	1.40	22.10	76.67	9	300	24.10	33.6	.
339	5.22	8	77315	19.0	25	0.42	T4120741	COURBIS	2.10	24.00	76.11	8	180	24.14	33.6	.
340	5.01	8	77320	17.7	31	0.29	T4120741	COURBIS	7.20	19.70	58.02	14	270	23.72	43.5	34.5
341	5.26	8	77320	18.2	26	0.40	T4120741	COURBIS	2.60	24.80	59.12	16	260	23.72	42.8	34.9

* NOT ENOUGH ACCEPTABLE STARS
R REJECTED IN FIRST ORDER COMPUTATION

APPENDIX B

ASTRONOMIC LONGITUDE SET DATA

Explanation of Appendix B

Data for each observed set of astronomic longitude are shown grouped by observer. Each observer's results are sorted in chronological order. The longitude value, set sigma, and azimuth correction are in arc seconds. YRGCD code of 77215 means Greenwhich Civil day 215, year 1977 or 3 August 1977. All local mean times are Mountain Standard times. The set sigma is a precision standard error of the longitude for the set. Wind azimuths reflect the direction from which the wind is blowing. Values of the wind azimuth are measured clockwise from magnetic north.

Items listed for each observed set are:

Column	Description
1	Set number.
2	Longitude value, arc seconds only.
3	Number of acceptable stars.
4	Year (2 digits) and Greenwich Civil day (3 digits).
5	Local mean civil time, hours.
6	Time span, minutes.
7	Precision standard error of set, arc seconds.
8	Instrument.
9	Observer.
10	Azimuth correction, arc seconds.
11	Sum of A factors.
12	Wind speed, knots.
13	Wind azimuth, degrees.
14	Atmospheric pressure, inches of Mercury.
15	Dry bulb temperature, degrees Fahrenheit.
16	Wet bulb temperature, degrees Fahrenheit.

THEODORE ASTRONOMIC LONGITUDE AT F.E. WARREN AFB, WY   104 DEGREES 51 MINUTES

SET	LONGITUDE SECONDS		STARS ACC	YRGCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	AZIMUTH CORR. SEC	SUM A	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
1	55.22		7	77215	22.95	56	0.11	T4120741	AUSTIN	-6.19	0.304	8	280	24.00	59.0	.
2	55.35		8	77215	24.05	43	0.09	T4120741	AUSTIN	-7.86	0.237	9	300	24.00	55.8	.
3	55.82		9	77215	24.97	54	0.04	T4120741	AUSTIN	-8.68	-0.177	7	290	24.00	52.5	.
4	55.51		9	77215	26.09	61	0.06	T4120741	AUSTIN	-9.39	-0.965	4	320	24.00	52.8	.
5	55.39	*	4	77217	22.60	49	0.04	T4120741	AUSTIN	-3.67	0.350	1	240	24.00	52.5	.
6	55.31		10	77221	23.73	67	0.07	T4120741	AUSTIN	-12.84	-0.228	2	270	23.92	54.8	.
7	55.39		8	77221	24.87	50	0.07	T4120741	AUSTIN	-12.99	-0.237	8	330	23.95	51.5	.
8	55.18		8	77221	25.83	45	0.07	T4120741	AUSTIN	-15.57	0.119	8	350	23.94	52.0	.
9	55.01		10	77221	26.85	58	0.04	T4120741	AUSTIN	-13.68	-0.042	11	330	23.97	52.5	.
10	55.18		7	77222	21.91	66	0.09	T4120740	AUSTIN	-16.86	-0.607	1	60	24.08	58.2	.
11	55.66		8	77222	23.04	55	0.03	T4120740	AUSTIN	-15.61	-0.553	2	50	24.08	55.5	.
12	55.46		8	77224	24.04	53	0.05	T4120740	AUSTIN	-15.22	0.322	1	240	24.12	46.0	.
13	55.92		8	77224	25.12	61	0.05	T4120740	AUSTIN	-15.90	-0.392	6	300	24.10	44.0	.
14	55.99		9	77225	22.44	95	0.08	T4120740	AUSTIN	-19.92	0.360	12	355	23.95	59.2	.
15	56.01		9	77225	23.79	58	0.06	T4120740	AUSTIN	-19.71	0.474	11	340	23.96	57.8	.
16	55.34		9	77225	25.03	67	0.09	T4120740	AUSTIN	-19.21	-1.248	8	320	23.98	55.5	.
17	55.48		6	77225	26.09	41	0.09	T4120740	AUSTIN	-17.28	0.540	10	330	23.99	53.5	.
18	55.38		9	77226	22.22	75	0.07	T4120737	AUSTIN	-0.30	0.267	12	150	23.91	62.5	.
19	55.45		9	77226	23.71	65	0.04	T4120737	AUSTIN	-1.08	-0.203	12	160	23.94	60.0	.
20	55.25		10	77226	25.08	87	0.04	T4120737	AUSTIN	0.39	-0.584	11	190	23.95	59.0	.
21	55.14		6	77215	22.96	56	0.11	T4120740	WHITE	-1.18	-0.102	8	280	24.00	59.0	.
22	55.24		9	77215	23.99	50	0.04	T4120740	WHITE	-0.57	0.258	9	300	24.00	55.8	.
23	55.39		7	77215	24.97	54	0.05	T4120740	WHITE	0.48	-0.255	7	290	24.00	52.5	.
24	55.59		9	77215	26.09	61	0.05	T4120740	WHITE	0.96	-0.965	4	320	24.00	52.8	.
25	54.99		5	77217	22.60	49	0.12	T4120740	WHITE	-26.20	0.645	1	240	24.00	52.5	.
26	55.10		9	77221	23.73	67	0.04	T4120740	WHITE	-17.57	0.905	2	270	23.92	54.8	.
27	55.08		8	77221	24.87	50	0.04	T4120740	WHITE	-16.24	-0.237	8	330	23.95	51.5	.
28	54.98		8	77221	25.83	45	0.06	T4120740	WHITE	-15.30	0.119	8	350	23.94	52.0	.
29	55.41		10	77221	26.90	64	0.07	T4120740	WHITE	-14.75	-0.374	11	330	23.97	52.5	.
30	55.25		8	77222	21.91	66	0.11	T4120737	WHITE	-9.40	-0.312	1	60	24.08	58.2	.
31	55.45		9	77222	23.20	74	0.08	T4120737	WHITE	-8.65	-0.619	2	50	24.08	55.5	.
32	54.72		10	77224	23.93	67	0.05	T4120737	WHITE	-3.33	0.732	1	240	24.12	46.0	.
33	55.06		8	77224	25.12	61	0.13	T4120737	WHITE	-4.39	-0.392	6	300	24.10	44.0	.
34	55.20		12	77225	22.38	102	0.07	T4120737	WHITE	-11.80	0.497	12	355	23.95	59.2	.
35	55.26		10	77225	23.79	58	0.06	T4120737	WHITE	-10.90	0.340	11	340	23.96	57.8	.
36	55.05		9	77225	25.03	67	0.10	T4120737	WHITE	-10.14	-1.248	8	320	23.98	55.5	.
37	54.77		8	77225	26.09	41	0.06	T4120737	WHITE	-10.44	-0.053	10	330	23.99	53.5	.
38	54.95		9	77226	22.22	75	0.05	T4120741	WHITE	1.55	0.079	12	150	23.91	62.5	.
39	54.96		11	77226	23.61	77	0.04	T4120741	WHITE	2.68	0.494	12	160	23.94	60.0	.
40	55.37		11	77226	25.08	87	0.10	T4120741	WHITE	1.30	-1.146	11	190	23.95	59.0	.
41	55.22	*	4	77217	22.74	32	0.12	T4120737	SALVERMOSER	-5.08	0.536	1	240	24.00	52.5	.
42	55.12		9	77221	23.79	60	0.02	T4120737	SALVERMOSER	-6.30	-0.250	2	270	23.92	54.8	.
43	55.44		8	77221	24.86	50	0.07	T4120737	SALVERMOSER	-4.80	-0.237	8	330	23.95	51.5	.
44	55.21		8	77221	25.93	45	0.06	T4120737	SALVERMOSER	-2.76	0.119	8	350	23.94	52.0	.
45	55.19		10	77221	26.90	64	0.08	T4120737	SALVERMOSER	-3.91	-0.276	11	330	23.97	52.5	.
46	54.51		6	77222	21.91	66	0.09	T4120741	SALVERMOSER	-10.06	-0.514	1	60	24.08	58.2	.
47	54.79		9	77222	23.04	55	0.07	T4120741	SALVERMOSER	-11.56	-0.553	2	50	24.08	55.5	.
48	54.48		9	77224	23.93	67	0.07	T4120741	SALVERMOSER	-7.60	0.438	1	240	24.12	46.0	.
49	55.31		8	77224	25.12	61	0.08	T4120741	SALVERMOSER	-9.97	-0.392	6	300	24.10	44.0	.
50	55.56		10	77225	22.38	102	0.09	T4120741	SALVERMOSER	-10.38	0.328	12	355	23.95	59.2	.
51	54.97		10	77225	23.79	58	0.08	T4120741	SALVERMOSER	-10.44	0.340	11	340	23.96	57.8	.
52	55.50		9	77225	25.03	67	0.05	T4120741	SALVERMOSER	-9.91	-1.248	8	320	23.98	55.5	.
53	54.56		9	77225	26.09	41	0.07	T4120741	SALVERMOSER	-12.30	-0.053	10	330	23.99	53.5	.
54	55.91		9	77226	22.21	95	0.04	T4120740	SALVERMOSER	-9.58	-0.065	12	150	23.91	62.5	.
55	55.21		10	77226	23.61	77	0.09	T4120740	SALVERMOSER	-10.38	-0.100	12	160	23.94	60.0	.
56	55.53		10	77226	25.08	87	0.09	T4120740	SALVERMOSER	-8.59	-1.755	11	190	23.95	59.0	.
57	55.19		9	77232	19.33	50	0.07	T4120740	CADDESS	-12.54	-0.688	8	230	24.09	60.8	.
58	55.67		8	77232	20.83	90	0.06	T4120740	CADDESS	-10.24	-0.818	7	240	24.10	57.2	.
59	55.52		8	77232	22.33	62	0.06	T4120740	CADDESS	-9.66	-0.483	6	230	24.10	54.8	.
60	55.39		8	77232	23.36	45	0.07	T4120740	CADDESS	-9.62	-0.308	6	245	24.10	52.5	.
61	55.71		7	77236	20.04	48	0.11	T4120740	CADDESS	-11.74	-0.313	8	120	23.92	66.2	.
62	55.74		8	77236	22.03	58	0.10	T4120740	CADDESS	-10.73	-0.331	12	150	23.94	62.0	.
63	55.45		9	77236	23.29	57	0.07	T4120740	CADDESS	-10.30	-0.017	8	165	23.96	58.2	.
64	55.65		8	77236	24.29	43	0.04	T4120740	CADDESS	-9.66	-0.224	3	165	23.98	56.2	.
65	55.43		8	77237	24.95	64	0.13	T4120737	CADDESS	4.50	0.313	10	280	23.85	58.8	.

* NOT ENOUGH ACCEPTABLE STARS
R REJECTED IN FIRST ORDER COMPUTATION

THEODORE ASTRONOMIC LONGITUDE AT F.E. WARREN AFB, WY 104 DEGREES 51 MINUTES

SET	LONGITUDE SECONDS		STARS ACC	YRSCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	AZIMUTH CORR. SEC	SUM A	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
66	55.30		8	77238	20.24	89	0.09	T4120737	CADDESS	1.06	-0.351	3	255	23.80	62.0	.
67	55.32		9	77238	23.43	49	0.07	T4120737	CADDESS	2.25	0.252	3	260	23.80	55.0	.
68	55.36		8	77238	24.55	57	0.12	T4120737	CADDESS	2.23	-0.149	8	250	23.80	54.0	.
69	54.97		7	77238	25.54	53	0.05	T4120737	CADDESS	2.65	-0.378	3	245	23.79	53.0	.
70	55.31		7	77242	21.84	58	0.12	T4120737	CADDESS	7.98	-0.094	3	85	24.01	54.2	.
71	55.42		8	77242	22.84	50	0.17	T4120737	CADDESS	9.12	-0.105	3	100	24.00	51.2	.
72	55.89		8	77242	23.80	53	0.07	T4120737	CADDESS	9.21	-0.223	2	115	24.00	54.5	.
73	55.42		8	77242	24.77	38	0.10	T4120737	CADDESS	9.50	0.159	5	115	24.00	57.0	.
74	55.74		9	77244	19.60	59	0.10	T4120740	CADDESS	-5.53	-0.703	16	135	24.05	56.8	.
75	55.77		8	77244	20.72	51	0.09	T4120740	CADDESS	-4.33	0.339	11	150	24.06	53.8	.
76	55.91		8	77244	21.65	47	0.08	T4120740	CADDESS	-4.21	-0.154	12	150	24.07	52.0	.
77	55.20		9	77244	22.70	60	0.05	T4120740	CADDESS	-4.26	-0.232	14	145	24.07	51.8	.
78	54.94		6	77232	19.59	50	0.09	T4120737	ZEIGLER	-24.73	-0.155	8	230	24.09	60.8	.
79	55.41		8	77232	20.84	90	0.10	T4120737	ZEIGLER	-23.37	-0.818	7	240	24.10	57.2	.
80	55.06		8	77232	22.33	62	0.06	T4120737	ZEIGLER	-23.83	-0.483	6	230	24.10	54.8	.
81	55.44		9	77232	23.36	45	0.08	T4120737	ZEIGLER	-21.75	0.308	6	245	24.10	52.5	.
82	55.09		8	77233	24.32	89	0.06	T4120737	ZEIGLER	6.60	-0.161	8	330	24.02	58.5	.
83	55.46		8	77236	20.08	43	0.14	T4120737	ZEIGLER	-7.32	-0.512	8	120	23.92	66.2	.
84	54.74		7	77236	21.93	46	0.05	T4120737	ZEIGLER	-7.62	-0.230	12	150	23.94	62.0	.
85	54.95		8	77236	23.29	57	0.09	T4120737	ZEIGLER	-6.28	0.536	8	165	23.96	58.2	.
86	55.18		8	77236	24.29	43	0.09	T4120737	ZEIGLER	-6.16	-0.224	3	165	23.98	56.0	.
87	54.95		10	77237	24.82	82	0.07	T4120740	ZEIGLER	-11.22	-0.559	10	280	23.85	58.8	.
88	55.30		9	77238	20.24	89	0.10	T4120740	ZEIGLER	-7.59	-0.847	3	255	23.80	62.0	.
89	55.16		8	77238	23.43	49	0.09	T4120740	ZEIGLER	-4.98	0.137	3	260	23.80	55.0	.
90	54.82		9	77238	24.55	57	0.09	T4120740	ZEIGLER	-5.14	0.395	8	250	23.80	54.0	.
91	55.12		9	77238	25.54	53	0.12	T4120740	ZEIGLER	-2.67	0.078	3	245	23.79	53.0	.
92	55.37		9	77241	20.79	52	0.06	T4120740	ZEIGLER	-2.58	-1.250	10	240	24.18	50.4	.
93	55.19		8	77241	21.84	49	0.09	T4120740	ZEIGLER	-3.10	-0.506	11	210	24.19	48.5	.
94	55.44		8	77241	22.94	45	0.07	T4120740	ZEIGLER	-1.42	0.487	9	190	24.19	48.5	.
95	54.48		9	77242	21.89	63	0.07	T4120741	ZEIGLER	-0.29	-1.072	3	85	24.01	54.2	.
96	54.67		8	77242	22.89	43	0.11	T4120741	ZEIGLER	-0.81	-0.077	3	100	24.00	51.2	.
97	54.88		8	77242	23.80	53	0.06	T4120741	ZEIGLER	-0.16	-0.223	2	115	24.00	54.5	.
98	54.83		8	77242	24.77	38	0.05	T4120741	ZEIGLER	-0.55	0.159	5	115	24.00	57.0	.
99	54.60		9	77244	19.60	59	0.10	T4120741	ZEIGLER	-4.50	-0.703	16	135	24.05	56.8	.
100	54.46		8	77244	20.72	51	0.08	T4120741	ZEIGLER	-4.75	0.339	11	150	24.06	53.8	.
101	54.56		8	77244	21.66	47	0.07	T4120741	ZEIGLER	-5.40	-0.154	12	150	24.07	52.0	.
102	54.26		8	77244	22.70	60	0.07	T4120741	ZEIGLER	-6.15	0.108	14	145	24.07	51.8	.
103	61.15	R	5	77257	22.24	37	0.18	T4120737	PERELKA	-4.02	0.901	5	205	24.02	48.5	45.0
104	51.18	*	4	77257	23.11	53	0.09	T4120737	PERELKA	-8.79	0.865	6	210	24.02	46.5	43.0
105	55.10		6	77258	19.67	60	0.11	T4120737	PERELKA	7.06	0.086	9	180	23.88	56.5	44.0
106	55.15		8	77258	20.85	63	0.09	T4120737	PERELKA	8.37	-0.972	10	180	23.88	55.0	43.0
107	55.23		8	77259	21.82	40	0.07	T4120737	PERELKA	7.62	-0.179	8	180	23.88	55.0	43.5
108	54.75		8	77258	22.68	51	0.05	T4120737	PERELKA	7.87	-0.308	9	210	23.88	54.0	43.8
109	55.31		7	77260	22.61	43	0.06	T4120737	PERELKA	-3.60	-0.602	2	290	23.84	44.0	37.5
110	55.19		8	77260	23.65	42	0.13	T4120737	PERELKA	-2.02	0.278	4	270	23.94	44.8	37.0
111	55.03		9	77260	24.75	73	0.09	T4120737	PERELKA	-2.31	-0.050	4	280	23.85	46.2	37.8
112	55.32		7	77261	19.44	56	0.12	T4120737	PERELKA	4.02	-0.052	8	310	23.90	52.5	41.5
113	55.68		8	77261	20.71	56	0.12	T4120740	PERELKA	-12.31	-1.066	10	320	23.92	50.2	39.5
114	55.85		7	77261	21.65	43	0.12	T4120740	PERELKA	-7.36	-0.299	7	320	23.94	48.2	38.0
115	55.46		8	77261	22.51	43	0.12	T4120740	PERELKA	-8.02	0.082	6	315	23.96	47.2	36.8
116	55.60		8	77261	23.52	38	0.06	T4120740	PERELKA	-5.65	0.159	9	335	23.95	46.8	36.2
117	54.97		9	77262	22.58	43	0.12	T4120740	PERELKA	-11.87	-1.074	4	275	24.11	37.5	33.2
118	55.48		8	77262	23.44	36	0.06	T4120740	PERELKA	-11.72	0.383	3	270	24.12	38.0	33.2
119	54.85		8	77262	24.47	45	0.05	T4120740	PERELKA	-12.27	-0.507	4	250	24.12	39.5	34.0
120	54.95		9	77262	25.44	62	0.12	T4120740	PERELKA	-12.39	0.204	4	240	24.12	36.5	32.2
121	54.65		8	77263	23.27	47	0.11	T4120741	PERELKA	5.43	0.179	7	240	23.87	52.8	43.0
122	54.70		9	77263	24.26	54	0.12	T4120741	PERELKA	3.63	-0.872	6	270	23.88	49.5	41.5
123	54.75		3	77263	25.37	47	0.09	T4120741	PERELKA	3.69	0.603	4	275	23.88	49.0	39.2
124	55.66	R	7	77267	18.85	53	0.06	T4120741	PERELKA	-4.00	-0.180	10	170	23.82	47.2	34.8
125	54.47		9	77267	20.15	76	0.09	T4120741	PERELKA	-5.63	-1.040	8	170	23.84	47.5	35.5
126	54.11		8	77267	21.21	41	0.10	T4120741	PERELKA	-6.39	-0.063	6	170	23.85	46.5	35.0
127	54.70		9	77267	22.09	51	0.06	T4120741	PERELKA	-6.09	-0.842	6	170	23.86	45.8	34.0
128	55.19		8	77257	23.13	38	0.10	T4120741	PERELKA	-4.29	0.096	12	170	23.67	47.0	34.2
129	55.03		8	77257	22.24	37	0.10	T4120741	PHILLIPS	-1.91	0.469	5	205	24.02	48.5	45.0
130	55.08		8	77257	23.11	53	0.07	T4120741	PHILLIPS	-1.92	0.022	5	210	24.02	46.5	43.0

* NOT ENOUGH ACCEPTABLE STARS
R REJECTED IN FIRST ORDER COMPUTATION

THEODORE ASTRONOMIC LONGITUDE AT F.E. WARREN AFB, WY 104 DEGREES 51 MINUTES

SET	LONGITUDE SECONDS	STARS ACC	YRSCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	AZIMUTH CORR. SEC	SUM A	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
131	55.11	7	77258	19.67	60	0.11	T4120741	PHILLIPS	1.99	0.133	9	180	23.88	56.5	44.0
132	55.26	9	77258	20.85	63	0.10	T4120741	PHILLIPS	1.83	-1.073	10	180	23.88	55.0	43.0
133	54.52	8	77258	21.82	40	0.06	T4120741	PHILLIPS	1.08	-0.179	8	180	23.88	55.0	43.5
134	54.88	8	77258	22.68	51	0.05	T4120741	PHILLIPS	1.36	-0.308	9	180	23.88	54.0	43.8
135	54.70	8	77260	22.66	49	0.10	T4120741	PHILLIPS	-6.24	-0.287	1	290	23.84	44.0	37.5
136	54.70	8	77260	23.65	42	0.12	T4120741	PHILLIPS	-5.85	0.278	4	270	23.84	44.8	37.0
137	55.28	10	77260	24.75	73	0.13	T4120741	PHILLIPS	-6.00	-1.452	4	280	23.85	46.2	37.8
138	54.94	7	77261	19.44	56	0.07	T4120741	PHILLIPS	1.71	0.536	8	310	23.90	52.5	41.5
139	55.21	8	77261	20.71	56	0.07	T4120737	PHILLIPS	6.63	-1.370	10	320	23.92	50.2	39.5
140	55.75	7	77261	21.64	43	0.08	T4120737	PHILLIPS	4.33	-0.605	7	320	23.94	48.2	38.0
141	55.72	8	77261	22.51	48	0.13	T4120737	PHILLIPS	7.85	0.082	6	315	23.96	47.2	36.8
142	55.43	8	77261	23.52	38	0.07	T4120737	PHILLIPS	8.47	0.159	9	335	23.96	46.8	36.2
143	54.79	8	77262	22.53	49	0.13	T4120737	PHILLIPS	4.02	-0.287	4	275	24.11	37.5	33.2
144	55.21	5	77262	23.44	36	0.12	T4120737	PHILLIPS	5.02	0.383	3	270	24.12	38.0	33.2
145	54.90	11	77262	24.36	58	0.06	T4120737	PHILLIPS	5.29	-1.526	4	250	24.12	39.5	34.0
146	54.88	10	77262	25.44	62	0.09	T4120737	PHILLIPS	7.06	0.098	4	240	24.12	36.5	32.2
147	55.50	8	77263	23.26	47	0.09	T4120740	PHILLIPS	1.91	0.179	7	240	23.87	52.8	43.0
148	55.59	9	77263	24.22	51	0.02	T4120740	PHILLIPS	3.66	-0.765	6	270	23.88	49.5	41.5
149	55.60	8	77263	25.44	55	0.03	T4120740	PHILLIPS	5.01	0.603	4	275	23.88	49.0	39.2
150	54.87	6	77267	18.85	53	0.08	T4120740	PHILLIPS	-7.06	0.161	10	170	23.82	47.2	34.8
151	54.49	9	77267	20.15	76	0.06	T4120740	PHILLIPS	-7.86	-1.040	8	170	23.84	47.5	35.5
152	54.27	8	77267	21.21	41	0.08	T4120740	PHILLIPS	-8.31	-0.063	6	170	23.85	46.5	35.0
153	54.55	9	77267	22.09	51	0.10	T4120740	PHILLIPS	-8.46	-0.842	6	170	23.86	45.8	34.0
154	54.62	8	77267	23.13	38	0.07	T4120740	PHILLIPS	-6.93	0.096	12	170	23.87	47.0	34.2
155	55.38	7	77257	22.24	37	0.12	T4120740	ROBERTS	-9.90	0.102	5	205	24.02	48.5	45.0
156	55.27	8	77257	23.11	53	0.08	T4120740	ROBERTS	-10.90	0.022	6	210	24.02	46.5	43.0
157	55.47	8	77260	22.66	49	0.07	T4120740	ROBERTS	5.55	-0.287	1	290	23.84	44.0	37.5
158	55.42	8	77260	23.65	42	0.06	T4120740	ROBERTS	4.51	0.278	4	270	23.84	44.8	37.0
159	55.38	11	77260	24.75	73	0.06	T4120740	ROBERTS	4.93	-1.355	4	280	23.85	46.2	37.8
160	55.69	8	77261	19.44	56	0.14	T4120740	ROBERTS	-9.91	0.196	8	310	23.90	52.5	41.5
161	55.27	9	77261	20.71	56	0.08	T4120741	ROBERTS	2.63	-0.808	10	370	23.92	50.2	39.5
162	54.54	8	77261	21.65	43	0.04	T4120741	ROBERTS	2.43	-0.077	7	320	23.94	48.2	38.0
163	54.64	8	77261	22.51	48	0.11	T4120741	ROBERTS	0.72	0.082	6	315	23.96	47.2	36.8
164	55.33	7	77261	23.52	38	0.06	T4120741	ROBERTS	1.14	-0.284	9	335	23.96	46.8	36.2
165	55.03	8	77262	22.53	49	0.08	T4120741	ROBERTS	-6.01	-0.287	4	275	24.11	37.5	33.2
166	55.15	7	77262	23.44	36	0.09	T4120741	ROBERTS	-6.72	0.408	3	270	24.12	38.0	33.2
167	54.73	11	77262	24.36	58	0.10	T4120741	ROBERTS	-7.95	-1.526	4	250	24.12	39.5	34.0
168	54.94	9	77262	25.50	55	0.12	T4120741	ROBERTS	-8.61	0.094	4	240	24.12	36.5	32.2
169	55.12	6	77263	23.37	35	0.08	T4120737	ROBERTS	8.52	-0.318	7	240	23.87	52.8	43.0
170	54.91	7	77263	24.31	61	0.11	T4120737	ROBERTS	8.70	-0.529	6	270	23.88	49.5	41.5
171	55.08	8	77263	25.37	47	0.07	T4120737	ROBERTS	9.94	0.603	4	275	23.88	49.0	39.2
172	55.27	8	77267	18.85	53	0.06	T4120737	ROBERTS	1.35	0.276	10	170	23.82	47.2	34.8
173	55.33	9	77267	20.15	76	0.11	T4120737	ROBERTS	0.82	-1.040	8	170	23.84	47.5	35.5
174	55.12	8	77267	21.21	41	0.06	T4120737	ROBERTS	-2.95	-0.063	6	170	23.85	46.5	35.0
175	55.36	9	77267	22.09	51	0.04	T4120737	ROBERTS	-2.35	-0.842	6	170	23.86	45.8	34.0
176	54.97	8	77267	23.13	38	0.08	T4120737	ROBERTS	-3.10	0.096	12	170	23.87	47.0	34.2
177	54.93	8	77270	22.23	56	0.06	T4120740	ROBERTS	-13.78	-0.261	4	170	23.96	46.2	39.2
178	55.62	8	77270	23.18	46	0.09	T4120740	ROBERTS	-13.02	0.284	1	170	23.97	44.2	38.2
179	54.92	9	77270	24.06	40	0.07	T4120740	ROBERTS	-13.77	-0.988	2	170	23.98	43.5	37.8
180	55.11	8	77270	24.91	47	0.09	T4120740	ROBERTS	-13.65	0.603	4	170	24.00	43.0	37.5
181	55.35	8	77285	20.02	50	0.16	T4120737	FINCH	-19.54	0.276	12	235	24.22	20.0	.
182	55.52	9	77285	20.99	53	0.13	T4120737	FINCH	-21.28	-1.024	8	250	24.22	18.0	.
183	55.84	9	77286	18.91	76	0.10	T4120737	FINCH	-2.28	-0.684	4	220	24.12	45.5	32.2
184	55.43	8	77286	20.00	45	0.06	T4120737	FINCH	-1.45	-0.147	5	255	24.12	43.2	31.0
185	55.53	7	77286	21.03	67	0.11	T4120737	FINCH	-0.98	-0.139	4	230	24.12	42.5	30.5
186	55.72	8	77286	22.03	45	0.13	T4120737	FINCH	-0.43	0.863	5	300	24.10	44.2	31.2
187	55.67	8	77287	21.26	48	0.08	T4120737	FINCH	-5.75	0.531	10	300	24.09	42.5	33.0
188	54.82	8	77287	22.13	38	0.14	T4120737	FINCH	-7.29	0.604	8	310	24.10	41.5	32.8
189	55.20	9	77287	22.94	39	0.08	T4120737	FINCH	-4.98	-0.855	8	305	24.10	39.2	31.8
190	55.40	7	77287	23.91	49	0.05	T4120737	FINCH	-4.06	-0.233	6	270	24.10	37.0	30.8
191	55.61	10	77288	18.51	79	0.12	T4120740	FINCH	-11.28	-1.188	3	310	24.18	48.2	40.8
192	55.87	6	77288	19.78	55	0.17	T4120740	FINCH	-9.55	-0.225	1	250	24.24	44.2	39.2
193	55.58	8	77289	21.13	48	0.08	T4120740	FINCH	0.66	0.066	2	300	24.18	36.2	32.5
194	55.44	8	77289	22.00	38	0.05	T4120740	FINCH	1.17	0.452	4	285	24.17	37.2	31.5
195	55.50	9	77289	22.97	59	0.07	T4120740	FINCH	1.35	-1.344	4	265	24.14	39.2	32.5

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THEODORE ASTRONOMIC LONGITUDE AT F.E. WARREN AFB, WY 104 DEGREES 51 MINUTES

SET	LONGITUDE SECONDS		STARS ACC	YRSCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	AZIMUTH CORR. SEC	SUM A	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
196	55.70		7	77289	23.96	48	0.08	T4120740	FINCH	2.34	0.269	4	265	24.12	44.0	35.0
197	56.08		8	77290	18.64	76	0.08	T4120740	FINCH	-7.43	-0.699	4	260	24.00	48.5	36.2
198	55.36		8	77290	19.70	41	0.11	T4120740	FINCH	-7.14	-0.063	2	295	24.00	51.5	37.2
199	55.37		10	77291	18.58	76	0.09	T4120741	FINCH	-0.98	-0.421	14	5	24.04	42.5	33.8
200	55.34		7	77291	19.68	43	0.03	T4120741	FINCH	-4.77	-0.150	12	5	24.05	38.5	31.5
201	55.21		9	77291	20.59	53	0.07	T4120741	FINCH	-4.50	-0.088	10	5	24.07	39.0	32.2
202	55.17		8	77291	21.56	38	0.07	T4120741	FINCH	-5.26	0.095	7	15	24.07	40.0	33.0
203	55.09		8	77292	21.59	50	0.05	T4120741	FINCH	-3.76	0.217	10	285	24.00	41.2	32.0
204	54.94		10	77292	22.69	68	0.11	T4120741	FINCH	-5.71	-1.477	10	285	24.00	39.2	30.5
205	55.50		8	77292	23.76	48	0.04	T4120741	FINCH	-5.66	0.572	12	280	24.00	39.2	30.2
206	55.41		8	77292	24.62	41	0.05	T4120741	FINCH	-6.82	-0.264	13	280	24.00	39.2	30.2
207	54.63	R	9	77285	19.97	55	0.13	T4120741	ZELLERS	-1.77	0.508	12	235	24.22	20.0	.
208	55.34		8	77285	20.99	53	0.08	T4120741	ZELLERS	-1.53	-0.462	8	250	24.22	18.0	.
209	55.38		9	77286	18.91	76	0.06	T4120741	ZELLERS	0.30	-0.684	4	220	24.12	45.5	32.2
210	55.37		8	77286	20.00	45	0.05	T4120741	ZELLERS	-0.34	-0.147	5	255	24.12	43.2	31.0
211	55.53		8	77286	21.03	67	0.06	T4120741	ZELLERS	0.67	-0.449	4	230	24.12	42.5	30.5
212	55.68		8	77286	22.03	44	0.09	T4120741	ZELLERS	0.66	0.626	5	300	24.10	44.2	31.2
213	55.38		9	77287	21.26	48	0.05	T4120741	ZELLERS	-6.00	0.531	10	300	24.09	42.5	33.0
214	55.37		8	77287	22.13	38	0.04	T4120741	ZELLERS	-6.75	0.604	8	310	24.10	41.5	32.8
215	55.48		9	77287	22.94	39	0.06	T4120741	ZELLERS	-6.03	-0.859	8	305	24.10	39.2	31.8
216	55.53		8	77287	23.92	49	0.10	T4120741	ZELLERS	-5.29	0.322	6	270	24.10	37.0	30.8
217	55.73		10	77288	19.62	84	0.04	T4120737	ZELLERS	-12.78	-0.838	3	310	24.18	48.2	40.8
218	55.77		12	77288	20.15	90	0.06	T4120737	ZELLERS	-10.47	0.228	1	250	24.24	44.2	39.2
219	55.24		7	77289	21.13	48	0.08	T4120737	ZELLERS	-4.59	-0.249	2	300	24.18	38.2	32.5
220	55.72		8	77289	22.00	38	0.08	T4120737	ZELLERS	-5.58	0.452	4	285	24.17	37.2	31.5
221	55.92		9	77289	22.97	59	0.13	T4120737	ZELLERS	-4.12	-1.344	4	255	24.14	39.2	32.5
222	56.01		7	77289	23.96	48	0.10	T4120737	ZELLERS	-5.14	0.924	4	265	24.12	44.0	35.0
223	55.56		9	77290	18.64	76	0.09	T4120737	ZELLERS	-5.25	-0.967	4	260	24.00	48.5	36.2
224	56.65	R	8	77290	19.70	41	0.07	T4120737	ZELLERS	-3.10	-0.063	2	295	24.00	51.5	37.2
225	55.85		10	77291	18.58	76	0.06	T4120740	ZELLERS	-9.07	-0.421	14	5	24.04	42.5	33.8
226	56.07		8	77291	19.68	42	0.09	T4120740	ZELLERS	-7.66	-0.490	12	5	24.05	38.5	31.5
227	55.98		8	77291	20.59	53	0.05	T4120740	ZELLERS	-7.00	-0.088	10	5	24.07	39.0	32.2
228	55.91		8	77291	21.56	38	0.10	T4120740	ZELLERS	-7.09	0.095	7	15	24.07	40.0	33.0
229	55.52		7	77292	21.59	50	0.13	T4120740	ZELLERS	6.24	0.036	10	285	24.00	41.2	32.0
230	56.12		10	77292	22.69	68	0.09	T4120740	ZELLERS	6.75	-1.477	10	285	24.00	39.2	30.5
231	56.33		8	77292	23.76	48	0.13	T4120740	ZELLERS	7.41	0.572	12	280	24.00	39.2	30.2
232	55.89		8	77292	24.62	41	0.11	T4120740	ZELLERS	6.93	-0.264	13	280	24.00	39.2	30.2
233	55.21		9	77285	19.97	55	0.07	T4120740	BARTON	-9.96	0.508	12	235	24.22	20.0	.
234	55.67		9	77285	20.99	53	0.09	T4120740	BARTON	-10.59	-1.024	8	250	24.22	18.0	.
235	55.39		9	77286	18.81	88	0.04	T4120740	BARTON	-9.35	-0.441	4	220	24.12	45.5	32.2
236	55.32		8	77286	20.00	45	0.05	T4120740	BARTON	-8.59	-0.147	5	255	24.12	43.2	31.0
237	55.55		7	77286	21.04	67	0.09	T4120740	BARTON	-6.03	-0.707	4	230	24.12	42.5	30.5
238	55.16		8	77285	22.03	44	0.10	T4120740	BARTON	-6.40	0.316	5	300	24.10	44.2	31.2
239	55.44		7	77287	21.26	48	0.07	T4120740	BARTON	-2.14	-0.003	10	300	24.09	42.5	33.0
240	55.11		8	77287	22.13	38	0.11	T4120740	BARTON	-3.33	0.604	8	310	24.10	41.5	32.8
241	55.26		10	77287	23.01	47	0.07	T4120740	BARTON	-1.62	-1.538	8	305	24.10	39.2	31.8
242	55.43		8	77287	23.92	49	0.10	T4120740	BARTON	-1.36	0.322	6	270	24.10	37.0	30.8
243	50.79	*	4	77288	18.54	75	0.16	T4120741	BARTON	-12.69	-0.329	3	310	24.18	48.2	40.8
244	55.11		12	77288	20.06	89	0.06	T4120741	BARTON	-4.43	1.047	1	250	24.24	44.2	39.2
245	55.42		8	77289	21.13	48	0.09	T4120741	BARTON	-7.83	0.066	2	300	24.18	38.2	32.5
246	55.22		8	77289	22.00	38	0.10	T4120741	BARTON	-8.24	0.452	4	285	24.17	37.2	31.5
247	54.35		8	77289	22.97	59	0.06	T4120741	BARTON	-8.16	-1.774	4	265	24.14	39.2	32.5
248	54.25	R	8	77289	23.96	48	0.08	T4120741	BARTON	-8.44	0.666	4	265	24.12	44.0	35.0
249	54.57		9	77290	18.64	76	0.08	T4120741	BARTON	-13.98	-0.967	4	260	24.00	48.5	36.2
250	55.10		7	77290	19.70	41	0.12	T4120741	BARTON	-16.83	0.071	2	295	24.00	51.5	37.2
251	54.79		8	77291	18.64	69	0.10	T4120737	BARTON	-2.85	0.099	14	5	24.04	42.5	33.8
252	54.96		7	77291	19.68	42	0.15	T4120737	BARTON	3.03	-0.711	12	5	24.05	38.5	31.5
253	54.26		7	77291	20.59	53	0.10	T4120737	BARTON	1.18	0.158	10	5	24.07	39.0	32.2
254	53.94	R	6	77291	21.56	38	0.11	T4120737	BARTON	0.93	0.004	7	15	24.07	40.0	33.0
255	54.84		7	77292	21.59	50	0.05	T4120737	BARTON	3.51	0.149	10	285	24.00	41.2	32.0
256	55.28		10	77292	22.69	69	0.09	T4120737	BARTON	4.74	-1.477	10	265	24.00	39.2	30.5
257	55.01		7	77292	23.76	43	0.12	T4120737	BARTON	5.59	0.834	12	280	24.00	39.2	30.2
258	54.80		7	77292	24.62	41	0.13	T4120737	BARTON	1.98	0.187	13	280	24.00	39.2	30.2
259	54.90		9	77293	20.35	58	0.10	T4120740	BERNARD	-16.39	-0.753	1	295	23.89	42.0	31.5
260	55.22		7	77293	21.53	50	0.13	T4120740	BERNARD	-15.67	0.046	3	255	23.90	42.5	32.0

* NOT ENOUGH ACCEPTABLE STARS
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THEODORE ASTRONOMIC LONGITUDE AT F.E. WARREN AFB, WY   104 DEGREES   51 MINUTES

SET	LONGITUDE SECONDS	STARS ACC	YRGCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	AZIMUTH CORR. SEC	SUM A	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
261	55.86	7	77299	18.30	46	0.06	T4120740	BERNARD	-3.54	-0.141	6	240	23.88	52.2	39.2
262	55.43	8	77299	19.13	40	0.14	T4120740	BERNARD	-0.95	-0.272	5	250	23.88	46.8	36.2
263	55.63	9	77299	19.99	51	0.06	T4120740	BERNARD	0.51	-0.843	3	200	23.89	45.5	35.8
264	55.75	8	77299	20.91	47	0.11	T4120740	BERNARD	0.95	0.439	5	280	23.89	46.2	36.0
265	55.35	7	77300	20.97	39	0.11	T4120740	BERNARD	-2.20	-0.124	6	230	23.88	41.0	32.0
266	55.56	9	77300	21.80	51	0.04	T4120740	BERNARD	-2.12	-0.242	5	285	23.88	41.8	32.0
267	55.91	7	77300	22.78	52	0.12	T4120740	BERNARD	-1.95	-0.023	3	320	23.87	41.0	33.0
268	55.08	6	77300	23.70	44	0.17	T4120740	BERNARD	-5.53	0.003	3	285	23.87	43.8	33.5
269	55.18	6	77301	18.48	44	0.13	T4120741	BERNARD	-5.46	0.116	4	160	23.92	40.0	34.2
270	55.21	8	77301	19.25	39	0.12	T4120741	BERNARD	-15.47	0.554	5	170	23.94	38.0	33.2
271	54.92	7	77301	20.20	56	0.11	T4120741	BERNARD	-16.08	-0.539	4	190	23.96	37.5	33.0
272	55.12	9	77301	21.15	46	0.08	T4120741	BERNARD	-19.06	-0.848	5	220	23.97	36.8	32.5
273	55.01	9	77302	18.00	59	0.09	T4120741	BERNARD	-0.52	-1.103	6	195	23.92	52.0	40.0
274	54.97	8	77302	18.91	42	0.11	T4120741	BERNARD	-1.20	0.030	4	195	23.92	48.5	38.0
275	54.72	8	77302	19.82	48	0.09	T4120741	BERNARD	-2.19	-0.236	5	215	23.92	47.5	37.2
276	54.84	8	77302	20.71	47	0.05	T4120741	BERNARD	-1.86	0.439	8	180	23.92	49.0	38.2
277	55.18	9	77307	18.44	45	0.10	T4120737	BERNARD	15.72	0.522	9	265	23.82	49.0	39.0
278	55.22	8	77307	19.38	52	0.04	T4120737	BERNARD	14.98	-0.511	7	260	23.82	46.0	37.0
279	54.68	8	77307	20.27	45	0.09	T4120737	BERNARD	15.35	0.448	7	260	23.82	43.5	36.0
280	54.71	9	77307	21.26	52	0.06	T4120737	BERNARD	16.30	-0.644	8	250	23.82	42.5	35.8
281	55.05	9	77308	22.27	53	0.07	T4120737	BERNARD	-8.64	0.580	5	180	24.02	34.0	32.0
282	54.95	9	77308	23.21	48	0.03	T4120737	BERNARD	-8.77	-0.835	5	210	24.02	24.0	.
283	54.95	9	77308	24.19	46	0.07	T4120737	BERNARD	-8.05	-0.164	5	215	24.02	22.0	.
284	55.26	8	77308	25.10	38	0.06	T4120737	BERNARD	-7.81	-0.002	4	170	24.00	21.5	.
285	55.08	9	77293	20.38	63	0.09	T4120737	WOODARD	-5.88	-0.922	1	295	23.89	42.0	31.5
286	55.38	8	77293	21.43	38	0.15	T4120737	WOODARD	-3.66	0.159	3	255	23.90	42.5	32.0
287	55.20	8	77299	18.30	46	0.10	T4120737	WOODARD	-11.97	0.076	6	240	23.88	52.2	39.2
288	55.55	7	77299	19.07	33	0.10	T4120737	WOODARD	-7.65	-0.057	5	250	23.88	46.8	36.2
289	55.85	7	77299	20.02	48	0.12	T4120737	WOODARD	-4.23	-0.285	3	200	23.89	45.5	35.8
290	55.51	8	77299	20.91	47	0.09	T4120737	WOODARD	-11.58	0.439	5	280	23.89	46.2	36.0
291	56.14	8	77300	20.97	39	0.08	T4120737	WOODARD	8.34	-0.056	6	230	23.88	41.0	32.0
292	55.73	9	77300	21.80	51	0.12	T4120737	WOODARD	7.62	-0.839	5	285	23.88	41.8	32.0
293	55.40	7	77300	22.78	52	0.10	T4120737	WOODARD	11.76	0.165	3	320	23.87	41.0	33.0
294	55.68	7	77300	23.70	44	0.15	T4120737	WOODARD	9.94	-0.370	3	285	23.87	43.8	33.5
295	55.98	9	77301	18.45	48	0.08	T4120740	WOODARD	-16.72	0.392	4	160	23.92	40.0	34.2
296	56.10	8	77301	19.25	39	0.07	T4120740	WOODARD	-16.99	0.554	5	170	23.94	38.0	33.2
297	56.26	8	77301	20.20	56	0.16	T4120740	WOODARD	-15.17	-0.282	4	190	23.96	37.5	33.0
298	55.89	9	77301	21.15	46	0.09	T4120740	WOODARD	-15.90	-0.848	5	220	23.97	36.8	32.5
299	56.28	9	77302	18.00	59	0.09	T4120740	WOODARD	-14.70	-1.108	6	195	23.92	52.0	40.0
300	56.29	8	77302	18.95	45	0.14	T4120740	WOODARD	-13.53	0.031	4	195	23.92	48.5	38.0
301	55.89	7	77302	19.82	47	0.09	T4120740	WOODARD	-11.61	-0.602	5	215	23.92	47.5	37.2
302	55.93	8	77302	20.71	47	0.09	T4120740	WOODARD	-9.21	0.439	8	180	23.92	49.0	38.2
303	55.19	9	77307	18.44	45	0.05	T4120741	WOODARD	-4.89	0.522	9	265	23.82	49.0	39.0
304	55.56	8	77307	19.38	52	0.07	T4120741	WOODARD	-4.05	-0.511	7	260	23.82	46.0	37.0
305	55.39	8	77307	20.27	45	0.09	T4120741	WOODARD	-5.76	0.448	7	260	23.82	43.5	36.0
306	55.72	9	77307	21.26	52	0.12	T4120741	WOODARD	-6.00	-0.644	8	250	23.82	42.5	35.8
307	55.84	10	77308	22.27	53	0.11	T4120741	WOODARD	-11.68	1.134	5	180	24.02	34.0	32.0
308	55.59	9	77308	23.21	48	0.09	T4120741	WOODARD	-13.84	-0.835	5	210	24.02	24.0	.
309	55.55	9	77308	24.15	51	0.09	T4120741	WOODARD	-15.66	-0.164	5	215	24.02	22.0	.
310	55.03	7	77308	25.10	38	0.11	T4120741	WOODARD	-16.29	0.167	4	170	24.00	21.5	.
311	55.47	9	77306	21.33	52	0.13	T4120737	COURBIS	-9.10	-0.644	20	275	23.88	32.0	.
312	55.42	7	77305	22.40	61	0.11	T4120737	COURBIS	-9.69	-0.669	12	270	23.86	32.0	.
313	56.13	8	77306	23.44	44	0.13	T4120737	COURBIS	-9.16	0.157	10	290	23.85	32.0	.
314	56.04	5	77305	24.50	55	0.18	T4120737	COURBIS	-9.36	-0.195	3	220	23.84	32.0	.
315	55.55	8	77307	18.44	45	0.11	T4120740	COURBIS	-8.02	0.301	9	265	23.82	49.0	39.0
316	55.31	8	77307	19.38	52	0.09	T4120740	COURBIS	-7.57	-0.511	7	260	23.82	46.0	37.0
317	55.80	8	77307	20.27	45	0.03	T4120740	COURBIS	-7.35	0.449	7	260	23.82	43.5	36.0
318	55.90	8	77307	21.26	52	0.04	T4120740	COURBIS	-7.20	-1.213	8	250	23.82	42.5	35.8
319	55.75	8	77308	22.27	53	0.06	T4120740	COURBIS	-22.08	0.020	5	160	24.02	34.0	32.0
320	55.51	8	77308	23.21	48	0.05	T4120740	COURBIS	-21.04	-0.678	5	210	24.02	24.0	.
321	55.65	9	77308	24.15	51	0.11	T4120740	COURBIS	-21.30	0.416	5	215	24.02	22.0	.
322	55.65	9	77308	25.10	38	0.11	T4120740	COURBIS	-20.82	-0.002	4	170	24.00	21.5	.
323	55.52	8	77309	18.61	43	0.13	T4120737	COURBIS	7.23	0.247	2	270	23.95	42.4	35.2
324	55.75	8	77309	19.45	49	0.08	T4120737	COURBIS	7.95	-0.288	1	270	23.95	41.8	35.1
325	55.35	9	77309	20.39	37	0.09	T4120737	COURBIS	7.11	0.072	3	290	23.95	37.9	32.4

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[illegible] ASTRONOMIC LONGITUDE AT F.E. WARREN AFB, WY 104 DEGREES 51 MINUTES

SET	LONGITUDE SECONDS	STARS ACC	YRGCD	LOCAL MEAN TIME HOURS	TIME SPAN MIN	SET SIGMA SEC	INSTRUMENT WILD	OBSERVER	AZIMUTH CORR. SEC	SUN A	WIND SPEED KNOTS	WIND AZIMUTH DEG	PRESSURE IN. HG	TEMPERATURE DRY DEG F	TEMPERATURE WET DEG F
326	55.30	8	77309	21.35	50	0.07	T4120737	COURBIS	8.28	-0.420	2	290	23.95	32.2	30.0
327	55.55	7	77314	23.21	44	0.06	T4120741	COURBIS	-0.91	-0.480	15	280	23.96	25.5	.
328	55.28	8	77314	24.08	50	0.05	T4120741	COURBIS	-0.91	0.096	14	290	23.98	24.8	.
329	55.82	8	77315	19.86	47	0.03	T4120741	COURBIS	-8.76	0.179	7	275	24.16	29.6	.
330	55.28	9	77315	20.82	51	0.05	T4120741	COURBIS	-9.60	-0.766	3	275	24.18	24.0	.
331	55.88	6	77315	21.72	42	0.06	T4120741	COURBIS	-9.87	0.540	5	280	24.20	25.0	.
332	55.66	8	77315	22.53	46	0.09	T4120741	COURBIS	-9.82	0.086	3	280	24.20	30.0	.
333	55.75	8	77316	18.08	51	0.11	T4120741	COURBIS	10.20	0.104	5	175	24.12	41.2	33.0
334	55.35	9	77316	19.46	87	0.09	T4120741	COURBIS	9.30	-1.094	10	200	24.12	40.8	33.6

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